THE ROLE OF COVEY DEMOGRAPHICS IN

NORTHERN BOBWHITE (*Colinus virginianus*) PRODUCTION

A Thesis

by

JASON LEE BROOKS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2005

Major Subject: Wildlife and Fisheries Sciences

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Approved as to style and content by:

Dale Rollins (Co-Chair of Committee)	R. Neal Wilkins (Co-Chair of Committee)
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ABSTRACT

The Role of Covey Demographics in

Northern Bobwhite (*Colinus virginianus*) Production.

(May 2005)

Jason Lee Brooks, B.S., Angelo State University

Co-Chairs of Advisory Committee: Dr. D. Rollins
Dr. R. N. Wilkins

Northern bobwhite (*Colinus virginianus*) populations are irruptive along their western periphery. Previous research has failed to identify the factors associated with these irruptions, but precipitation is often assumed to be a primary causal factor. I hypothesize that the mechanism may involve demographic variables, specifically that birds entering their second breeding season are more successful than subadult breeders. A better understanding of age-specific survival and productivity in quail populations may be beneficial if managing for a population with an older age structure could ameliorate the irruptive cycles. Radiotagged bobwhites (n > 100 each year; approximately equal numbers (25) of each age-sex class) were followed throughout the breeding season (Mar. – Aug.) in 2003 and 2004 in Fisher County, Texas. Survival, nesting attempts, hatch rate, and clutch size were monitored. Probability of survival of radiotagged birds during the breeding season was S = 0.465 and S = 0.395 in 2003 and 2004, respectively; survival was similar among all age-sex classes. Nest success was greater in 2004 (52.4%, n = 42) than 2003 (28.6%, n = 35) and the 2004 breeding season was at least 20 days longer, likely due to more summer rainfall and cooler temperatures.

Nest success was similar among adult and subadult hens in 2003 (4 of 21 adult nests, 6 of 14 subadult nests) and 2004 (16 of 28 adult nests, 7 of 14 subadult nests). Nest initiation was similar in 2003 (0.84 nests/adult hen vs. 0.61 nests/subadult hen), but adults initiated more nests than subadults in 2004 (1.04 nests/adult hen vs. 0.58 nests/subadult hen). Adult hens initiated 12 of 15 renesting attempts observed. Nest initiation dates and nest site selection were similar between adults and subadults. The adult:subadult ratios for 2003 and 2004 were 1:3.0 and 1:1.3 (n = 426 and n = 224, respectively). Extrapolating from the sample population, subadults contributed approximately 84% of the chicks fledged in 2003 but only 37% in 2004, while adults contributed 16% and 63% in 2003 and 2004, respectively. Results from this study suggest that if covey demographics are a component of bobwhite irruptions, the mechanism is most likely due to greater renesting effort by adult hens.

DEDICATION

This thesis is dedicated to my wife, Cara, and my son, Jase. Without their support and patience none of this would have been possible. I would also like to recognize my parents, Russell and Cindy Brooks, for their continued support of me and all my pursuits in life. They instilled the work ethic in me that allowed me to see this project through to completion. I would also like to thank Jim and Linda McKenzie for their support and encouragement.

ACKNOWLEDGEMENTS

Foremost, I thank the Aiken Ranch, L.P. for their support of this project. Specifically, I would like to thank Don and Ed Aiken for allowing access to the ranch and for their work, support, and occasional "harassment." They made me feel welcome and helped the project run as smoothly as possible. I also thank Nancy Aiken for dressing my wounds.

I recognize the Harvey Weil Sportsman's Trust for providing the seed money for this project. I also acknowledge Texas Council of Quail Unlimited, West Texas Chapter of the Safari Club International, Texas Agricultural Experiment Station, and all the Fisher County Quail Project donors for their financial support.

I recognize Ben Taylor for logistical support, coordinating the aid of student workers, and his technical assistance on the project. I thank Traci Williams, Krissa Rollins, David Harrison, Carrie Lewis, and Tommy Lynn Russell for logistical support.

I thank Dr. Neal Wilkins and Dr. Darrell Ueckert for their guidance and input on the project. Above all, I thank Dr. Dale Rollins for his continued belief in me, his commitment to this project, and time invested, both in the field and throughout the writing process.

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INTRODUCTION

One of the least understood aspects of northern bobwhite (*Colinus virginianus*) population dynamics is the irruptive (i.e., "boom-bust") phenomenon that characterizes the species along the western periphery of its range (Guthery 2000:164, Rollins 2002, Hernandez et al. 2002, Texas Parks and Wildlife 2004) (Fig. 1). The effects of rainfall (Guthery et al. 1988), phytoestrogens (Cain et al. 1987, Giuliano et al. 1996), heat (Guthery 2002:15), and other external stimuli (Spears et al. 1993, Lusk et al. 2002) have been examined but none have satisfactorily explained the phenomenon. The stimulus(i) may originate in the demography of the bobwhite population. Some basic questions about bobwhite mating strategies, e.g., age-specific productivity, have not been investigated. Perhaps hens that survive for >1 year exhibit higher nest success either from beginning the nesting season earlier, being more physiologically fit (i.e., producing multiple clutches [Sermons and Speake 1987, Curtis et al 1993, Peoples et al. 1996]), or through the benefit of "experience" that parlays into greater hatch rates or better nest site selection. The proportion of older hens to subadult hens would be greater in the breeding season following a year of poor reproduction (i.e., a "bust" year) (Buntyn 2004). If adult hens did indeed express greater productivity, the demographics of the quail population could ostensibly allow quail populations to recover more quickly.

A better understanding of demography and age-specific productivity may aid in understanding the irruptive nature of bobwhite populations in their western range and may aid in fine-tuning harvest regulations that might buffer or ameliorate the

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This thesis follows the style and format of the Wildlife Society Bulletin.

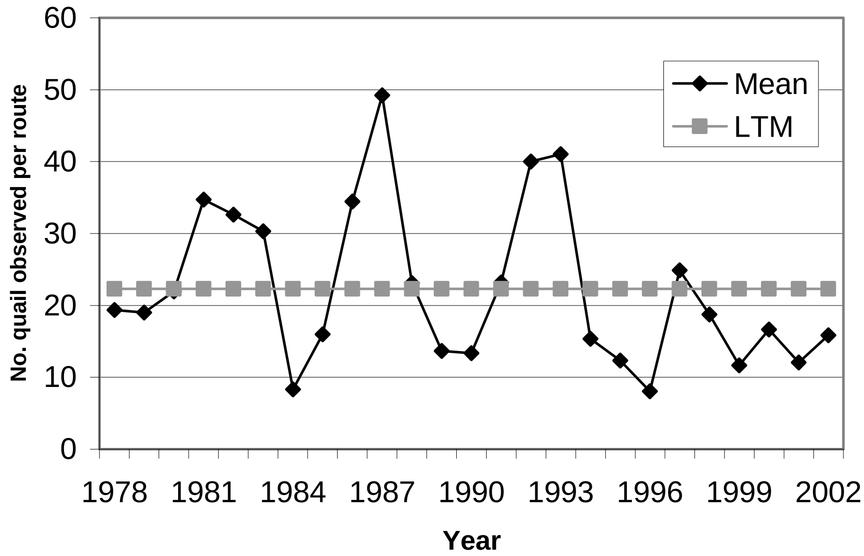

Figure 1. Bobwhite population trends recorded via roadside surveys for the Rolling Plains of Texas 1978–2003 (Texas Parks and Wildlife 2004). LTM denotes the long-term mean.

fluctuations in quail numbers over years.

Survival

Rosene (1969:135) stated, "as a rule, somewhere between 70 and 80 percent of quail die every year." Pollock et al. (1989) concluded that adult quail survived at slightly higher rates than juveniles and that males tended to survive at greater rates than females based on leg-band recovery in Florida. This leads to a male-biased sex ratio commonly observed in bobwhite populations (Lehmann 1984:18). Guthery and Lusk (2004) concluded that survival rates reported from telemetry studies were unreasonably low. Cox et al. (2004) documented survival rates of radiotagged birds 2.3 times lower than survival suggested by harvest ratios. Radiotagged individuals may be more susceptible to predation due to negative physiological impacts (Osborne et al. 1997). Hernandez et al. (2004) speculated that radiotagging may induce behavioral changes that could predispose radiotagged birds to greater rates of predation.

Breeding season survival rates for bobwhite have ranged from 33% in North Carolina (Curtis et al. 1988), 33% in Mississippi (Burger et al. 1995), 40% in Florida (Curtis et al. 1988), to 41% in Georgia over 5 years (Burger et al. 1995). Taylor et al. (2000) reported breeding season survival of northern bobwhites over a 4-year study ranged from 17-51% in Mississippi.

Reproductive ecology

Reproductive ecology of bobwhites is the least understood aspect of their biology (Curtis et al. 1993). Studies of breeding behavior prior to the advent of radio telemetry

(Stoddard 1931, Rosene 1969) were unable to identify several reproductive strategies that bobwhites employ. Some behaviors (e.g., double-clutching, brood abandonment) relative to bobwhite breeding can best be answered by radiotagging wild birds (Suchy and Munkel 1993).

Radio telemetry has dispelled the historical perception that bobwhites were strictly monogamous (Curtis et al. 1993, Peoples et al. 1996). Polygamous behavior, renesting following failed attempts, multiple clutching, and incubation of nests by males are strategies employed by bobwhites that may increase production (Burger et al. 1995, Guthery and Kuvleskey 1998). The flexible reproductive strategies of bobwhites allows them to compensate for high annual mortality rates and rapidly increase populations (Burger et al. 1995, Peoples et al. 1996).

Most female bobwhites incubate their first nest and, therefore, the ratio of sexually mature individuals not committed to nesting or brood-rearing becomes more male-biased as the nesting season progresses (Burger et al. 1995). Mated males may incubate a nest or assume parental duties, while females exploit the sex ratio to become polyandrous (Burger et al. 1995). Multiple brooding by a single female has been documented in Texas (Taylor 1991, Carter et al. 2002), Alabama (Sermons and Speake 1987), Florida (Curtis et al. 1993), North Carolina (Curtis et al. 1993), Iowa (Suchy and Munkel 1993), Missouri (Burger et al. 1995), and Oklahoma (Peoples et al. 1996). However, Guthery and Kuvlesky (1998) found that multiple-brooding had little effect on age structure of quail populations.

Communal brooding involves parents of different broods combining their broods and sharing responsibility of caring for young (Lott and Mastrup 1999). California quail (*Callipepla californica*) exhibit communal brooding which extends a hen's reproductive life span (Lott and Mastrup 1999).

Age-specific reproduction

In many species of birds, first-time breeders fledge fewer young than do older breeders (Curio 1982). Fowler (1995) speculated that subadult birds are less capable of reproduction than adults. Longer maturation rates and decreased production by subadults are common characteristics of long-lived birds such as Canada geese (*Branta canadensis maxima*) (Raveling 1981). Curio (1982) speculated that subadult birds might refrain from investing maximally in reproduction in order to enhance their future reproductive prospects. However, this concept seems more likely in long-lived than short-lived birds (Curio 1982).

Differences in age-specific reproduction have been reported for other ground-nesting birds. Wild turkeys (*Melagris gallopavo*), although longer-lived than bobwhites, experienced greater hatch rates, greater nest success, and potential production with increasing age in Virginia and West Virginia (Norman et al. 2001). Paisley et al. (1998) found that wild turkey hens nested at greater rates than subadults in Wisconsin. Roberts et al. (1995) observed greater production from adult turkey hens than subadult hens in New York.

Reproductive physiology

Photoperiod is a key factor in stimulating bobwhite reproduction (Baldini et al.

1952). In caged bobwhites, laying was more easily stimulated by modification of the photoperiod in older birds than in first-time breeders (Robinson 1963). Under normal daylight conditions, hens attain sexual maturity at 10-12 months of age, but when exposed to artificial light, reproduction can occur as early as 5 months (Kirkpatrick 1964). Parmalee (1955) suggested that subadult wild bobwhite hens nesting for the first time tended to nest later in the breeding season than older birds, but his data were insufficient to support this contention because of small sample size.

Robinson (1963) suggested that stress associated with reproduction increases the energy requirements of first-time breeders more than for older breeders. Hens that had experienced 1 breeding season were better suited to shift physiological emphasis from maintenance processes to reproductive functions. Klimstra and Roseberry (1975) acknowledged a potential differential in the productivity of subadult versus second-year bobwhite hens, but dismissed its impact due to the small proportion of second-year hens in the overall population. However, annual survival tends to be greater at more southern latitudes (Guthery 2002:48), thus in any given year southern populations would tend to have a greater percentage of adults in the population. In semi-arid environments, earlier nesting bobwhites were more productive than those that nested later (Guthery et al. 1988). Lehmann (1984:84) observed that most early nests were established by hens >1 year old (based on harvest analysis). Adult Gambel's quail (*C. gambelii*) paired earlier than subadults and earlier pairing was associated with larger brood size in this species (Hagelin 1999).

Pair bonds

Mating pairs that reunite in successive years typically enjoy greater reproductive success than newly-formed pairs in most avian species (Fowler 1995). In some species, pairs that have retained a pair bond from previous seasons lay earlier in the breeding season than newly formed pairs (Fowler 1995, Hagelin 1999). Stoddard (1931:19) speculated that bobwhites may maintain pair-bonds and that these surviving pairs may commit to the breeding season prior to other breeders. Young breeders in populations of some bird species may not be allowed access to the best resources, including territories, nest sites, and feeding areas that may be occupied by older birds (Curio 1982).

Although polygamous behavior is exhibited by bobwhites, some individuals remain mated for an entire season, and mate again the following season if both survive (Stoddard 1931:19). Burger et al. (1995) observed bobwhites remating in 64% of renesting attempts in the same season, when both members of a pair survived. Hagelin (1999) observed 4 cases in which Gambel's quail remated in subsequent years; each of these reunited pairs formed before the median pair date of the sample population. Lercel et al. (1999) concluded that mate loss in mallards (*Anas platyrhynchos*) during winter could inhibit reproductive success in some years.

Age structure of bobwhite populations

Roseberry and Klimstra (1984:136) speculated that "age-specific differential survival and reproduction would act to dampen population fluctuations because high production would increase the proportion of young in the population and thus reduce subsequent survival and reproduction. Guthery (2002:48) compiled mean age ratios (adults:subadults) of bobwhites for portions of their range in the United States. In southern latitudes, bobwhites sustained approximately 70% annual mortality and produced about 2.33 juveniles/adult across sex classes. In more northerly latitudes, bobwhites experienced 80% annual mortality and produced >4 juveniles/adult. In 34 counties in Illinois, harvest data indicated that overall age ratios ranged from 1:3.34 to 1:6.99 with an average of 1:5.00 (Roseberry and Klimstra 1984:136). Lehmann (1984:45) reported percentage of total number of juveniles in the winter population as 57.2% in 1943 and 38.1% in 1944. Fall percentages were 67.0% and 53.9% in 1943 and 1944, respectively. These fall values roughly translate to ratios of 1:2 and 1:1 adults to subadults. Wilkins (1987) reported age ratios of bobwhites in south Texas ranging from 1:2.28 to 1:11.8 based on banding and harvest data. Buntyn (2004) reported that age ratios in the breeding population of scaled quail in Pecos County, Texas changed abruptly from a dry year (1998; adult:subadult ratio of 3:1) to a wetter year (1999; adult:subadult ratio of 1:8).

Nest site selection

Bobwhites nest on the ground, generally in open areas in herbaceous cover produced the previous growing season (Rosene 1969:63). In south Texas, bobwhites preferred sturdy perennial grasses (Lehmann 1984:80), although grass structure (dimensions) may be more important than particular species. In southern Illinois, Klimstra and Roseberry (1975) found that grasses made up the protective cover at 69.9%

of nests, with forbs (22.6%) and woody cover (19.7%) used less frequently.

In the Rolling Plains of Texas, prickly pear (*Opuntia* spp.) has been identified as a common nesting substrate for bobwhite quail (Slater et al. 2001, Hernandez et al. 2003). Prickly pear may provide increased protection from nest depredation (Slater et al. 2001). Hernandez et al. (2003) speculated that bobwhites may use prickly pear to increase nest protection or in areas with limited bunchgrass availability, i.e., traditional nesting cover. Hernandez et al. (2003) did not compare use of prickly pear by adult and subadult bobwhite hens.

Nest depredation may limit recruitment in bobwhite populations (Rollins and Carroll 2001). Staller et al. (2002) did not find any differences in macrohabitat features surrounding successful and depredated nests in southern Georgia and Florida. In Kansas, bobwhites selected nesting microhabitat with taller vegetation that had greater visual obstruction than that in surrounding areas (Taylor et al. 1999). Hernandez (1999) reported that successful bobwhite nests in Shackelford County, Texas, were situated in macrohabitats that had greater densities of bunchgrasses and prickly pear than randomly sampled sites. Lehmann (1984:96) found that nests located in conspicuous grass clumps, i.e., those noticeably taller than surrounding vegetation, were subject to greater rates of depredation. Nests located in grasses that were indistinguishable from surrounding grasses or slightly shorter enjoyed greater success rates. Successful nests of Attwater's prairie-chickens (*Tympanuchus cupido attwateri*) were characterized by denser and taller vegetation at the nest site compared to that at unsuccessful nests (Lutz et al. 1994).

OBJECTIVES

The objectives of this study were to:

(1) determine if survival rates of bobwhites during the breeding season vary among age and/or sex classes.

(2) determine if reproductive success of adult and subadult bobwhite hens is different; and if so, determine if differences are related to hatching rate, nest site selection, and timing of nesting.

HYPOTHESES

H_0^1: Survival of bobwhites during the breeding season is similar among age and sex classes.

H_A^1: Adults survive at higher rates than subadults.

H_A^1: Males survive at higher rates than females.

H_O^2: Nest success does not differ among adult and subadult bobwhites.

H_A^2: Adults experience greater nesting success.

H_O^3: Nest initiation rates do not differ among adult and subadult bobwhites.

H_A^3: Adults initiate nests at a higher rate than subadults (i.e., multiple-clutching).

H_O^4: Nest initiation dates do not differ among adult and subadult bobwhites.

H_A^4: Adults initiate nesting earlier than subadults.

H_O^5: Nest site selection does not differ among adult and subadult bobwhites.

H_A^5: Adults select nesting habitats with taller and denser vegetation, or more prickly pear.

STUDY SITE

The study area was located on the 1,400-ha Aiken ranch located 20 km northwest of Sweetwater, in Fisher County, Texas. Vegetation (plant names follow Gould 1975) on the site was dominated by a honey mesquite (*Prosopis glandulosa* var. *glandulosa*) overstory with lesser amounts of netleaf hackberry (*Celtis reticulata*). Other common woody plants included catclaw mimosa (*Mimosa aculeaticarpa*), chittam (*Bumelia lanuginosa*), and prickly ash (*Zanthoxylum clava-herculis var. fruticosum*). The understory consisted of sideoats grama (*Bouteloua curtipendula*), silver bluestem (*Bothriochloa sacchariodes)*, three awns (*Aristida* spp.), buffalograss (*Buchloe dactyloides*), tobosa (*Hilaria mutica*), and yucca (*Yucca* spp.). Succulents common on the site included prickly pear and tasajillo (*O. leptocaulis*).

Since 2002, the study site was included in the Texas Quail Index, i.e., surveys coordinated by Texas Cooperative Extension which include whistling and roadside counts and other indices of quail abundance (Rollins et al. 2002). Those results indicated that the abundance of bobwhites on the study area was in the top quartile of areas monitored (D. Rollins, Texas Cooperative Extension, unpublished data). Rainfall data were recorded from a rain gauge at the ranch headquarters (Table 1).

Ranch management was focused primarily on enhancing wildlife populations. Supplemental feeders, food plots, moist-soil management (Buntyn 2004), and brush management have been implemented to increase quail populations. Cattle stocking rates were low since 1997, and typically only stocker animals were grazed for 6 months during winter. Stocker cattle were present only from November 2002 to May 2003.

Table 1. Monthly precipitation totals recorded (cm) at the Aiken Ranch headquarters, Fisher County, Texas, 2002 – 2004. The Aiken Ranch is an official monitoring site for the National Weather Service. Long-term means (LTM) were calculated from rainfall records of Abilene, Texas which began in 1885.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	1.42	2.87	7.49	2.51	10.26	5.21	7.44	1.98	6.58	8.00	2.18	5.61	61.57
2003	0.23	1.60	1.85	1.24	3.61	12.04	0.71	9.63	1.19	1.27	1.73	0.00	35.10
2004	3.18	5.94	5.18	8.03	1.42	14.15	9.80	15.39	5.51	11.13	12.19	2.06	93.98
LTM	1.91	2.54	2.54	4.45	7.62	6.99	5.08	5.72	10.16	6.35	2.54	1.91	57.79

METHODS

Trapping and handling

Bobwhites were trapped in late-winter (February – March 2003 and January – March 2004) using funnel traps (Stoddard 1931) baited with milo. The goal was to radiotag at least 25 adult and 25 subadult bobwhites of each sex (a total of 100 birds) each year. Quail were fitted with neckloop telemeters weighing < 7 g with a 4-hr mortality sensor (Wildlife Materials, Carbondale, Ill., USA in 2003, American Telemetry Enterprises, Tallahassee, Flor., USA in 2004) and monitored thrice weekly through the nesting season (Apr. – Sep.). A high rate of premature radio telemeter failure, apparently caused by poor battery life (R. Blanchard, Wildlife Materials, Inc., personal communication) occurred in 2003. In order to curb radio loss, I switched brands of telemeters for the 2004 breeding season (American Telemetry Enterprises, Tallahassee, Flor., USA). Birds were weighed to the nearest 5 g with hand-held scales. Additional trapped birds were leg-banded with numbered aluminum bands and released for future mark-recapture data. Trapping and handling protocols were conducted under Animal Use Protocol No. 2002-199 approved by Texas A&M University.

Monitoring

Radiotagged birds were located twice weekly by triangulation and once weekly by homing until a sighting was achieved. If a bird was located in the same location for 2 consecutive sightings, nest incubation was assumed. Upon locating a nest, a waypoint was recorded using a hand-held Global Positioning System (GPS) unit. When an incubating bird was determined to be away from the nest, the nest site was investigated; the nesting substrate was identified to the species level and the number of eggs was recorded. Nests were monitored until the eggs hatched or were depredated or were abandoned. Surviving birds were recaptured by flushing several times and then snared with nets at the conclusion of the 2003 breeding season. They were fitted with new telemeters and released for surveillance during fall and winter. When a bird mortality was detected, I attempted to classify the cause of death (e.g., avian- or mammalian-caused predation) by evidence available at the kill site (Carter et al. 2002).

Nest site characteristics

Line transect sampling was used to estimate potential nest site availability and percent vegetative cover. Each nest was marked by GPS and then subsequently located at the conclusion of the breeding season (i.e., August) for completion of vegetation sampling. Percent cover of standing vegetation at the nest bowl was estimated visually and height of the vegetation at the nest bowl was measured to the nearest cm within a 0.25-cm^2 quadrat placed over each nest bowl. A random heading was established at each nest site for (4) 40-m transect lines (oriented successively at 90-degree angles from the nest bowl). Data were recorded along these transect lines at 4-m increments using a 0.25-m^2 quadrat (40 quadrats per nest site) to generate mean percent vegetative cover, dominant species of vegetation, and height of tallest stems of forbs or the crown of the grasses (Fig. 2). Means were calculated for the 40 quadrat measures for use as replicates in statistical analysis. Nest site availability was estimated by counting all potential

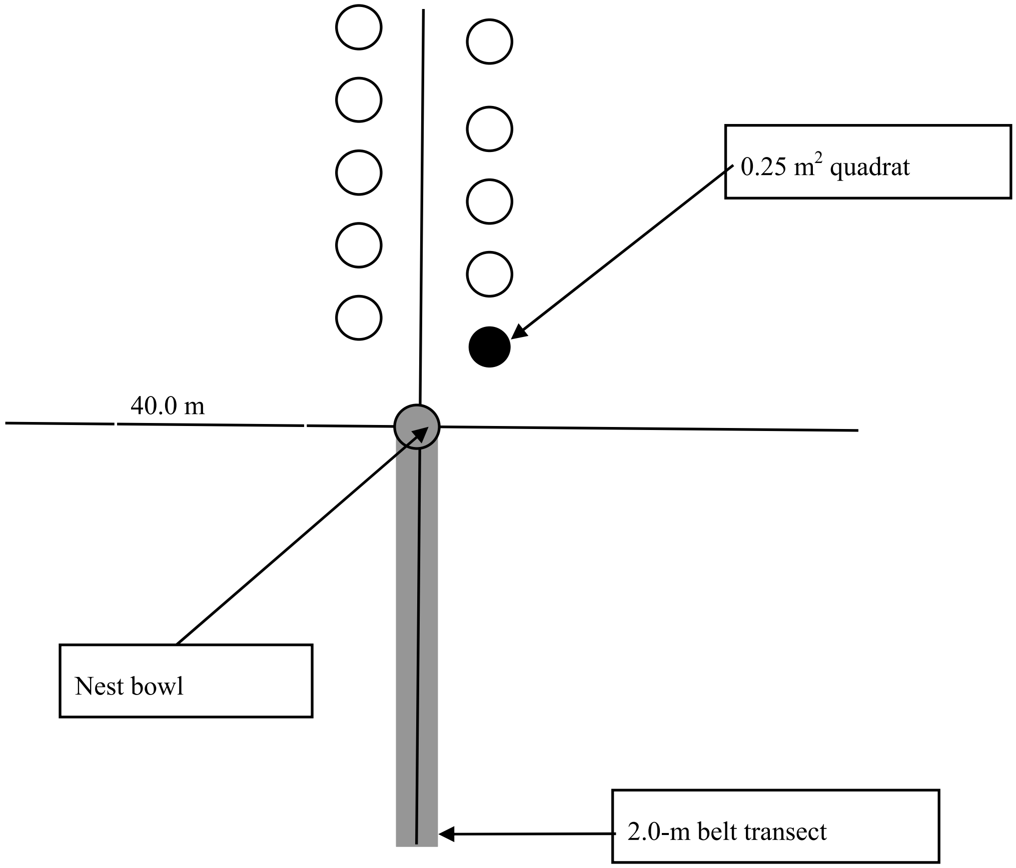

Figure 2. Diagram depicting how nest site measurements were obtained. Quadrat (0.25-m^2) and 2-m belt transect measures were repeated along each of the 4 transects. A distance to the nearest ranch road was measured from the nest bowl.

nest sites located within(4) 2.0-m-wide X 40-m-long belt transects at each nest site (Slater et al. 2001). Potential nest sites were classified as bunchgrass (> 20.0 cm in diameter), cacti (> 0.5 m^2), and yucca (> 15.0 cm in diameter). The mean value for each potential nest site category was then multiplied by 125 to convert to sites/ha. The distance from the nest bowl to the nearest ranch road was measured. These data were used to compare macrohabitats surrounding nest sites selected by subadults and adults and to compare macrohabitats surrounding successful and unsuccessful nest sites.

Statistical analysis

Probability of survival of radiotagged bobwhites was estimated and plotted using Kaplan-Meier analysis with staggered entry design (Pollock et al. 1989, Krebs 1999). Survival probabilities among age and sex classes and between years were compared using log-rank Chi-square analysis (Pollock et al. 1989, Krebs 1999). Birds surviving < 7 d post-release were censored from the survival analysis. Nesting success and nesting rate (multiple clutches) were analyzed using Chi-square analysis (SPSS 2002) to evaluate differences among age-sex classes. Students t-tests (SPSS 2002) were used to assess differences in nesting habitat variables.

RESULTS

Survival

<u>2003</u>

A total of 130 bobwhites was radiotagged in 2003 (31 adult males, 30 adult females, 36 subadult males, 33 subadult females). Mean mass of radiotagged adult and subadult females was 183.5 ± 1.2 g and 181.4 ± 1.4 g, respectively. An additional 296 birds were leg-banded. Survival probability estimates were developed for radiotagged bobwhites from March – mid-August. Sixty-six birds were censored because of radio failure or death within 7 days post-release. I visually identified 3 radiotagged bobwhites which were not producing a radio signal. I recovered 14 birds with non-functioning collars through trapping and harvest. Males were collared in order to study pair-bond fidelity during subsequent breeding seasons. However, only 2 pair of radiotagged bobwhites mated in my sample, and these 2 pairs did not survive to the second breeding season.

Finite survival probabilities, standard errors, and confidence intervals were developed for a 24-week period from Mar. 2 to Aug. 16 (Table 2). Weekly survival probabilities were plotted for each age/sex class (Fig. 3). Probability of survival did not differ among age or sex classes (Table 3). Probability of survival averaged over all age/sex classes was S = 0.465 in 2003. Radio failure and low numbers of radio collars prevented collection of sufficient fall-winter data for analysis.

<u>2004</u>

A total of 103 bobwhites was radiotagged in 2004 (24 adult males, 28 subadult

Table 2. Finite survival probability estimates ($S \pm$ SE) calculated using Kaplan-Meier staggered entry design (Pollock et al. 1989) for radiotagged bobwhites in Fisher County, Texas, Mar – Aug 2003 and 2004.

	2003				2004			
	S	SE	Lower CI	Upper CI	*S*	SE	Lower CI	Upper CI
Subadult Male	0.436	0.115	0.211	0.661	0.438	0.107	0.229	0.648
Subadult Female	0.515	0.107	0.304	0.725	0.449	0.102	0.249	0.648
Adult Male	0.439	0.148	0.15	0.729	0.379	0.099	0.186	0.573
Adult Female	0.559	0.101	0.361	0.757	0.467	0.091	0.288	0.645

Table 3. Log rank chi square comparisons (Pollock et al. 1989) of survival probabilities among different age-sex classes of radiotagged bobwhites in Fisher County, Texas, 2 Mar – 16 Aug 2003 and 11 Jan – 21 Aug 2004.

	2003		2004	
Comparison	X^2	*P*	X^2	*P*
subadults - male vs. female	0	1	0.98	0.32
adults - male vs. female	0.06	0.81	0.04	0.84
females - subadult vs. adult	0.07	0.79	0.74	0.39
males - subadult vs. adult	0.09	0.76	0.03	0.86
adults vs. subadults	0.22	0.64	0.5	0.48
males vs. females	0.09	0.76	0.65	0.42

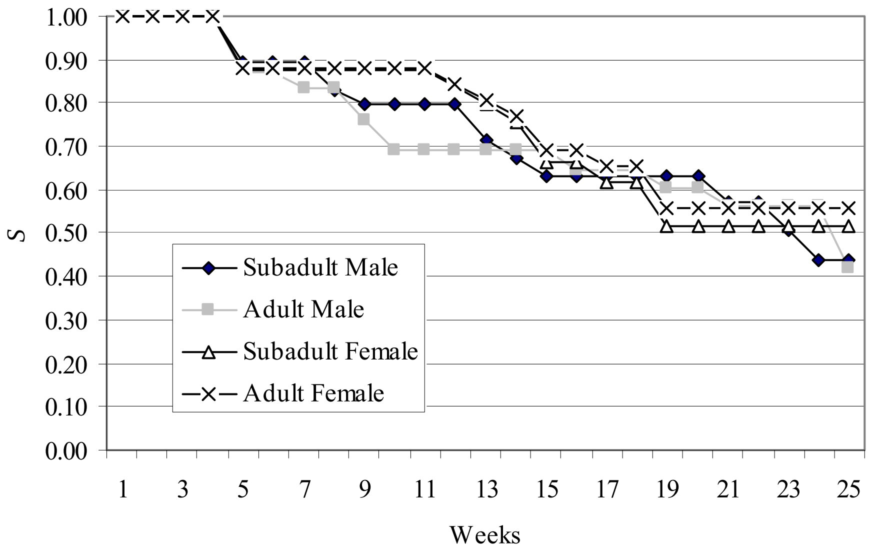

Figure 3. Weekly survival probabilities (*S*) observed for various age and sex classes of radiotagged bobwhites in Fisher County, Texas, 2003. The date for week 1 was 2-8 Mar 2003.

females, 25 subadult males, and26 adult females). Mean mass of radiotagged adult and subadult females was 187.1 ± 1.7 g and 181.4 ± 1.3 g, respectively. An additional 127 birds were leg-banded. Survival probability estimates were developed for Jan. 11– Aug. 19. Twenty-seven birds were censored because of radio failure or death within 7 days post-release. Finite survival values, standard errors, and confidence intervals were developed for a 32-week period from Jan. 11 to Aug. 21 (Table 2). Weekly survival probabilities during the same time period for each age/sex class are shown in Figure 4. Survival probabilities did not differ among age or sex classes (Table 3). Survival probabilities, averaged over all age/sex classes was $S = 0.395$ in 2004. Thirty leg-banded birds were recaptured in 2004 from a population of 230 quail banded the previous year, suggesting a crude annual survival rate of 0.13.

Cause-specific mortality was similar in 2003 and 2004 (Fig. 5). Unknown causes comprised the majority of mortalities ($n = 20$, 2003; $n = 25$, 2004). In most cases of unknown mortality, telemeters were found in the nests of southern plains wood rats (*Neotoma micropus*) with other evidence, primarily feathers. This ruled out the possibility of a slipped collar. Avian and mammalian predators were the 2 major sources of discernable mortality. One death was attributed to heat stress. A hail storm on March 21, 2004 was deemed the cause of 2 mortalities. Four bobwhites were killed and consumed by western diamondback rattlesnakes (*Crotalus atrox*) in 2004. Predation by Mexican ground squirrels (*Spermophilus mexicanus*) was observed within quail traps on 3 occasions, in which 4 birds were killed. Two ground squirrels were observed feeding on the carcass of a bobwhite hen outside of confinement, although I cannot conclusively

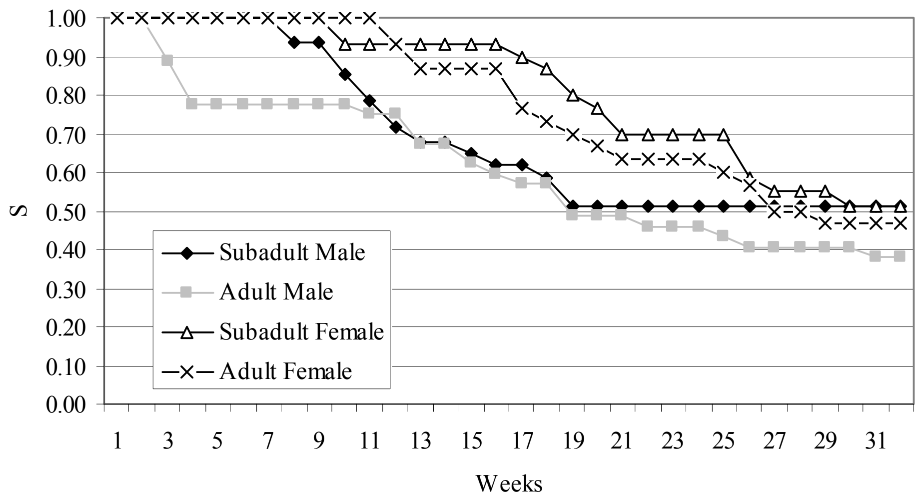

Figure 4. Weekly survival probabilities (*S*) observed for various age and sex classes of radiotagged bobwhites in Fisher County, Texas, 2003. The date for week 1 was 11-17 Jan 2004.

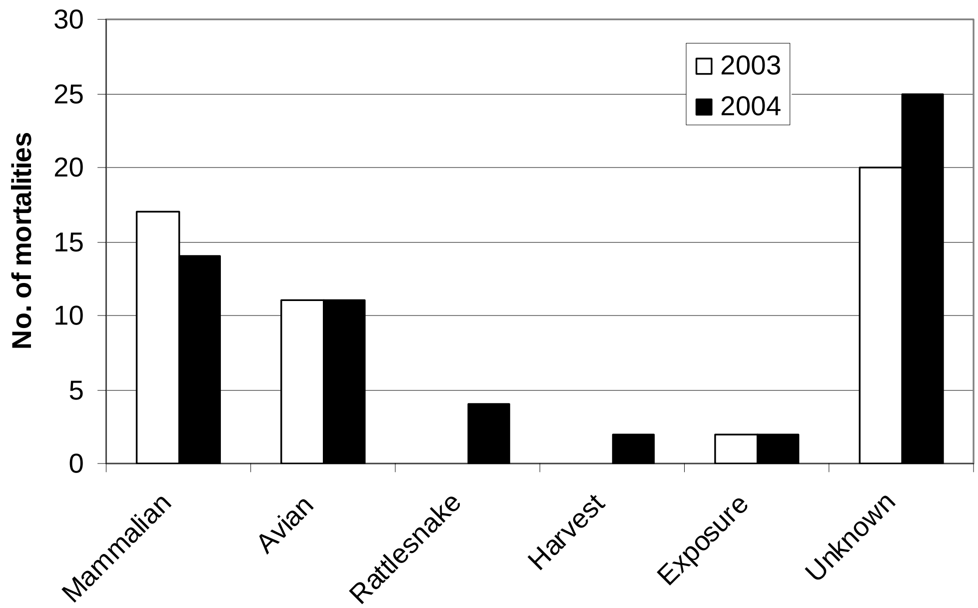

Figure 5. Cause-specific mortality observed in radiotagged bobwhites in Fisher County, Texas, 2003–2004.

report that the bird was killed by ground squirrels.

Nesting success

Nesting success was greater in 2004 than 2003 (52.4% vs. 28.6%; $\chi^2 = 8.27$; $P = 0.04$) (Table 4). Therefore nesting data for each year were analyzed separately. Onset of nesting did not differ between adult and subadult birds in either year (Fig. 6).

<u>2003</u>

Thirty-five nests (including 4 second nests) were located in 2003. The first nest was found on 5 May 2003 and the last nest hatched 28 July 2003. Subadult and adult bobwhite nests had similar hatch rates (0.26 nests hatched/hen vs. 0.16 nests hatched/adults, $\chi^2 = 0.02$, $P = 0.89$). Nest initiation was similar among age classes (0.84 nests/adult and 0.61 nests/subadult, $\chi^2 = 0.01$, $P = 0.92$). All 4 re-nesting attempts were initiated by adults. Males (1 adult, 1 subadult) incubated 2 nests, and a male assumed incubation of 1 nest (initiated by a subadult) when the female was killed. Adults averaged 11.7 ± 0.7 ($\bar{x} \pm SE$) eggs per nest ($n = 18$), while subadults averaged 12.3 ± 0.6 eggs per nest ($n = 11$). Number of eggs was not recorded for 6 nests because the nests were depredated before eggs could be counted. Number of chicks fledged was similar between age classes (1.56 chicks/adult hen vs. 2.65 chicks/subadult hen, $\chi^2 = 0.14$, $P = 0.71$)

<u>2004</u>

Forty-three nests (including 9 second nest attempts and 2 third attempts) were located in 2004. The first nest was found on 2 May 2004 and 3 nests were still active at

Table 4. Nesting statistics recorded for radiotagged bobwhites in Fisher County, Texas, 2003–2004.

Age Class	2003 (*n*=35)		2004 (*n*=42)		Overall (*n*=77)	
Attempt	Success	Failure	Success	Failure	Success	Failure
Adult						
1	3	14	11	9	14	23
2	1	3	4	2	5	5
3	0	0	1*	0	1	0
Total	4	17	16	11	20	28
Subadult						
1	6	8	6	6	12	14
2	0	0	2	1	2	1
Total	6	8	8	7	14	15
Grand Total	10	35	24	18	34	53

*One nest was omitted from analysis due to unknown fate

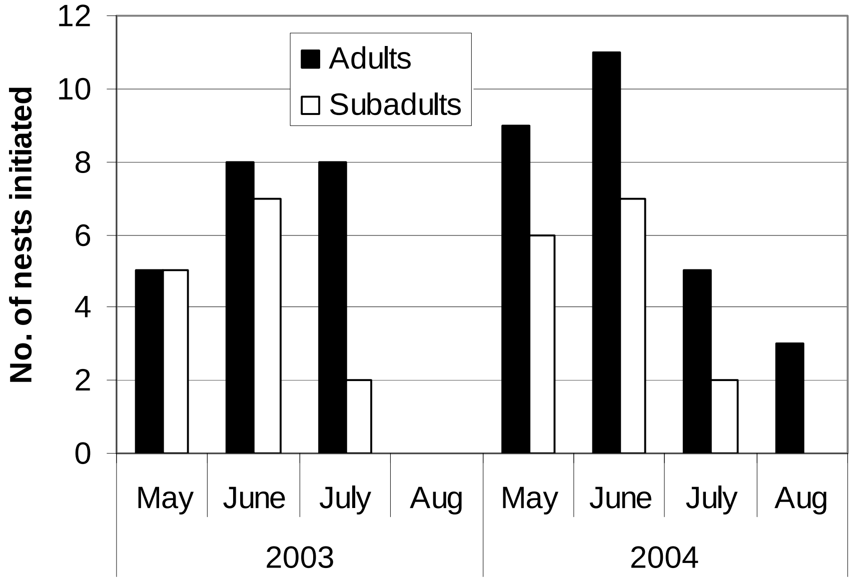

Figure 6. Nesting chronology observed for adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003–2004.

the end of data collection on 19 August 2004. Hatch rates did not differ among age classes (0.29 nests hatched/hen vs. 0.62 nests hatched/adults, $\chi^2 = 0.06$, $P = 1.0$). One nest was censored because it was still active when I left the study site and upon my return, eggshell evidence was not found. Adults initiated more nests than juveniles (1.04 nests/adult and 0.58 nests/subadult $\chi^2 = 0.07$, $P = 1.0$). Adults initiated 8 re-nesting attempts (including 2 third attempts), while subadults initiated 3. Adult males incubated 5 nests, while no subadult males incubated nests. Adult hens averaged 11.3 ± 0.6 eggs per nest ($n = 25$), while subadult hens averaged 12.4 ± 0.5 eggs per nest ($n = 11$). Numbers of eggs were not recorded for 7 nests because the nests were depredated before I could determine the clutch size. Number of chicks fledged was similar between age classes (6.19 chicks/adult hen vs. 3.36 chicks/subadult hen, $\chi^2 = 0.48$, $P = 0.49$).

Communal brooding

Communal brooding was observed on 3 occasions in 2003, but was not observed in 2004. Communal broods were reared by 2 females ($n = 1$), 2 pairs ($n = 1$), and 2 males ($n = 1$). All 3 associations were observed on at least 3 occasions. These repeated observations suggest that these were not adjacent coveys, but indeed communal broods.

Vegetation characteristics at nest sites

Texas wintergrass (*Stipa leucotricha*) and prickly pear were the most common nesting substrates in both years and were frequently used in conjunction with one another (Table 5). Yucca and three-awns were other common nesting substrates. Other

Table 5. Nesting substrates used by bobwhites both as stand alone substrates and in association with >1 other substrates in Fisher County, Texas, 2003–2004.

	Texas wintergrass	Prickly pear	Threeawn	Yucca	Other
2003					
Alone	8	0	3	4	2
Associated with >1 other substrate	12	9	3	4	2
2004					
Alone	1	0	4	1	8
Associated with >1 other substrate	16	14	6	2	0

grasses utilized included vine-mesquite (*Panicum obtusum*), silver bluestem, King Ranch bluestem (*Bothriochloa ischaemum var. songarica*), sideoats grama, tobosa, plains bristlegrass (*Setaria leucopila*), and Indiangrass (*Sorghastrum nutans*).

2003

In 2003, subadults selected nesting sites with a slightly greater percentage of standing vegetative cover than adults (88.9 ± 2.4 % vs. 80.2 ± 3.4%, t_{33} = 1.863; P = 0.071) (Fig. 7), but this difference is not likely of biological significance. There was no difference in height of vegetation among nests of adults and subadults (18.0 ± 1.1 cm and 22.5 ± 4.8 cm, respectively) (t_{33} = 0.966; P = 0.34) (Fig. 8). Characteristics of nesting microhabitat in 2003 did not differ in percentage of cover between successful and failed nests (86.5 ± 3.9% to 82.6 ± 3.0%) (t_{33} = – 0.739; P = 0.45) (Fig. 9). Height of vegetation was also similar among successful and failed nests (18.0 ± 1.6 cm and 20.0 ± 2.2 cm, respectively) (t_{33} = 0.535; P = 0.60) (Fig. 10).

Macrohabitat characteristics did not differ in percentage of vegetative cover (Fig. 11), height of vegetation (Fig. 12), or nest site availability within bunchgrass, cacti, yucca, or shrubs (Fig. 13) between age classes in 2003. Successful nests had significantly more potential prickly pear nesting sites than failed nests (1450 ± 300 and 650 ± 100 sites/ha, respectively; t_{34} = –3.30; P = 0.002) (Fig. 14). No differences were recorded for bunchgrasses (t_{34} = 0.90; P = 0.37), shrubs (t_{34} = 1.20; P = 0.24), or yucca (t_{34} = 0.32; P = 0.76). Height of vegetation and percentage of cover did not differ between successful and failed nests (Figs. 15, 16). Distance from the nest to the nearest road did not differ between nests initiated by subadult and adult bobwhites (40.6 ± 7.7

and 49.5 ± 12.1 m, respectively) (t_{31} = 0.65; P = 0.52) (Fig. 17), or between nest fates (56.8 ± 15.7 and 38.5 ± 6.5 m for hatched and failed nests, respectively (t_{31} = –1.29; P = 0.21) (Fig. 18).

<u>2004</u>

Nests initiated by adult bobwhites had a slightly greater percentage of ground cover at the nest bowl than those initiated by subadults (87.2 ± 1.8% and 79.6 ± 4.2%, respectively; t_{37} = -1.90; P = 0.065) (Fig. 7). Height of vegetation at nest bowls was similar between age classes (t_{37} = 0.37; P = 0.71) (Fig. 8). Percentage of cover did not differ between successful and failed nests (87.0 ± 1.8% and 81.8 ± 3.5%, t_{37} = -1.32; P = 0.20) (Fig. 9). Height of vegetation did not differ between successful and failed nests (14.4 ± 1.0 cm and 26.5 ± 7.6 cm respectively, t_{37} = 1.57; P = 0.13,) (Fig. 10).

Macrohabitat characteristics of nest sites of adult and subadult birds did not differ in percentage of standing vegetative cover (t_{38} = -0.58; P = 0.56) (Fig. 11), height of vegetation (t_{38} = 0.95; P = 0.35) (Fig. 12), or nest site availability (Fig. 19) in 2004. Nests of adult and subadult birds were established at similar distances from roads (56.2 m ± 9.2 and 35.0 m ± 11.5; t_{33} = -1.41; P = 0.17). Successful nests were characterized by a greater percentage of vegetative cover in the surrounding macrohabitat than failed nests (58.4 ± 2.1% and 50.0 ± 3.0%; t_{38} = –2.28; P = 0.028) (Fig. 15). Successful nests were located further from ranch roads than failed nests (61.8 ± 9.9 m to 30.3 ± 9.2 m, respectively; (t_{33} = –2.25; P = 0.031) (Fig. 18). Height of macrohabitat vegetation did not differ between successful and failed nests (t_{38} = -1.26; P = 0.21) (Fig. 16). No difference was recorded for nest site availability of successful and failed nests (Fig. 20).

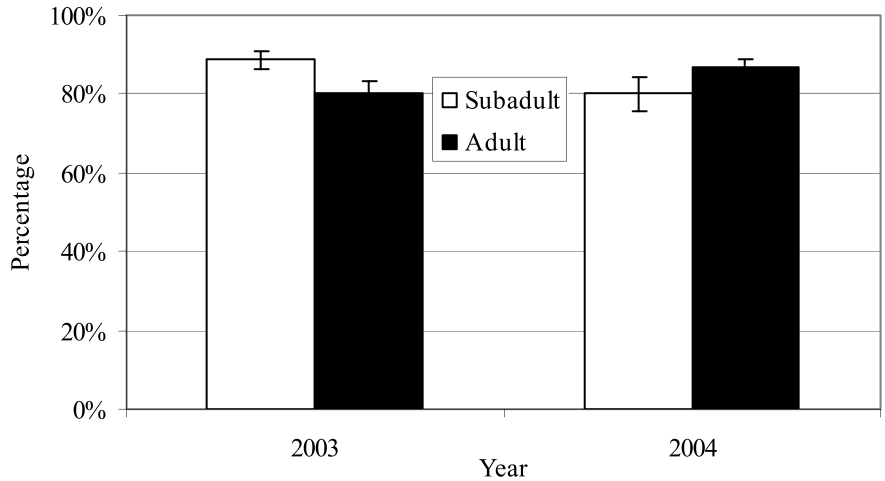

Figure 7. Percentage of standing vegetative cover observed by ocular estimate at nest bowls of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003–2004. Bars indicate standard error of the mean (SEM).

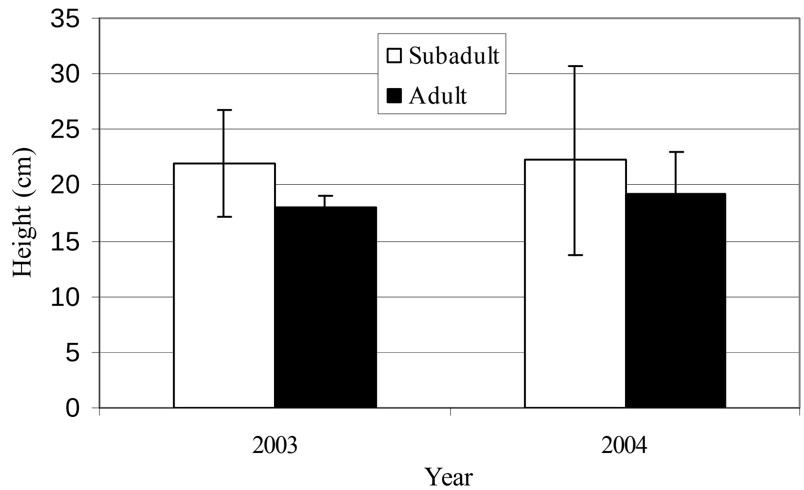

Figure 8. Height of vegetation (cm) observed at nest bowls of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003–2004.

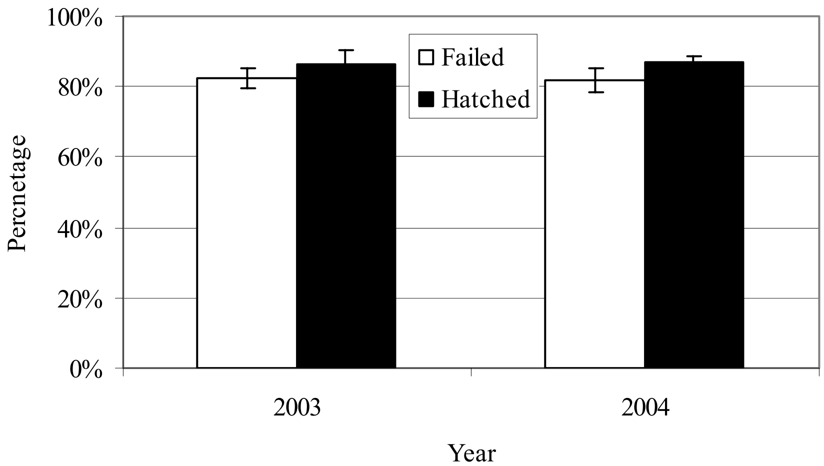

Figure 9. Percentage of standing vegetative cover observed at failed and hatched nest bowls in Fisher County, Texas, 2003–2004.

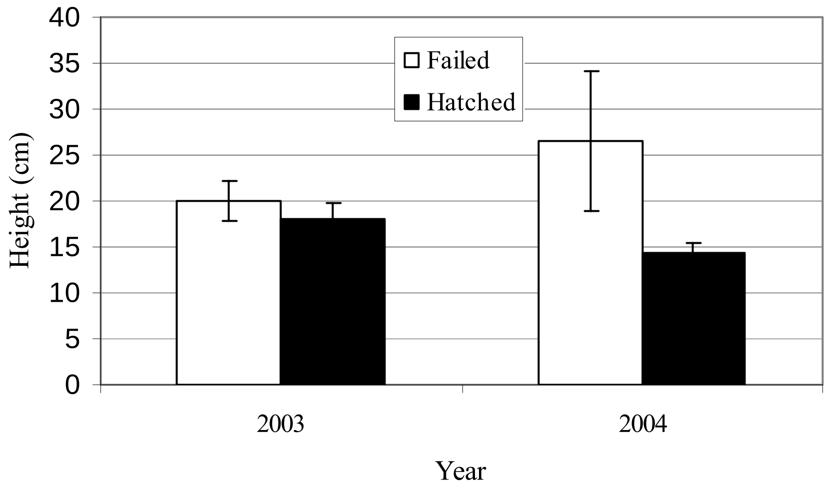

Figure 10. Height of vegetation (cm) observed at failed and hatched bobwhite nest bowls in Fisher County, Texas, 2003–2004.

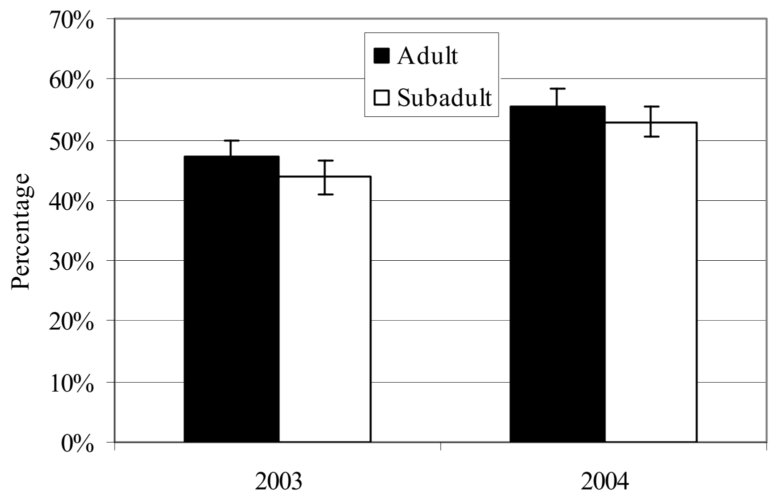

Figure 11. Mean percentage of standing vegetative cover observed in the macrohabitat surrounding nests of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003–2004. Means were determined by ocular estimates at 40 points surrounding the nest.

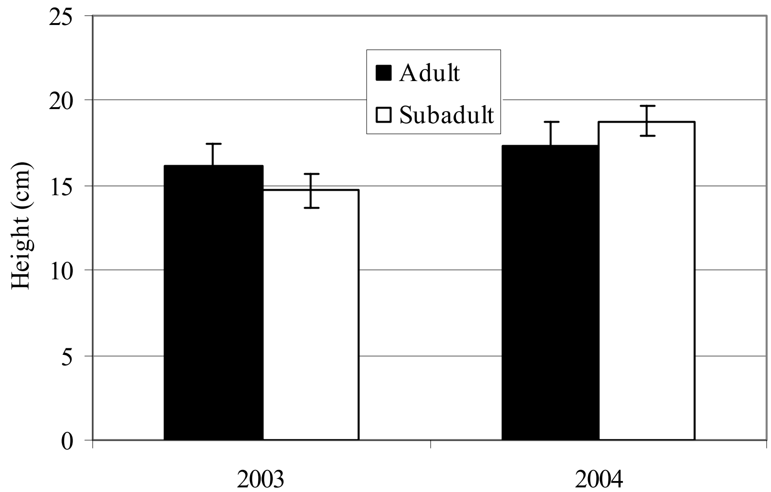

Figure 12. Mean height of vegetation (cm) observed in the macrohabitat surrounding nests of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003–2004.

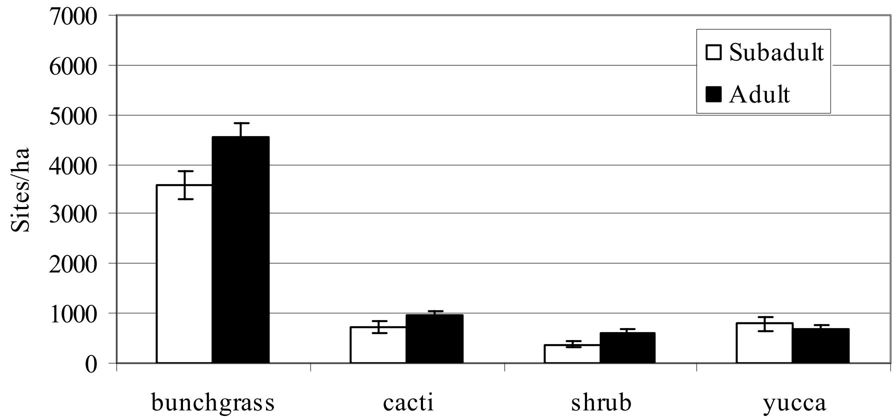

Figure 13. Potential nest sites (sites/ha) observed within a radius of 40 m of actual nest sites of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003.

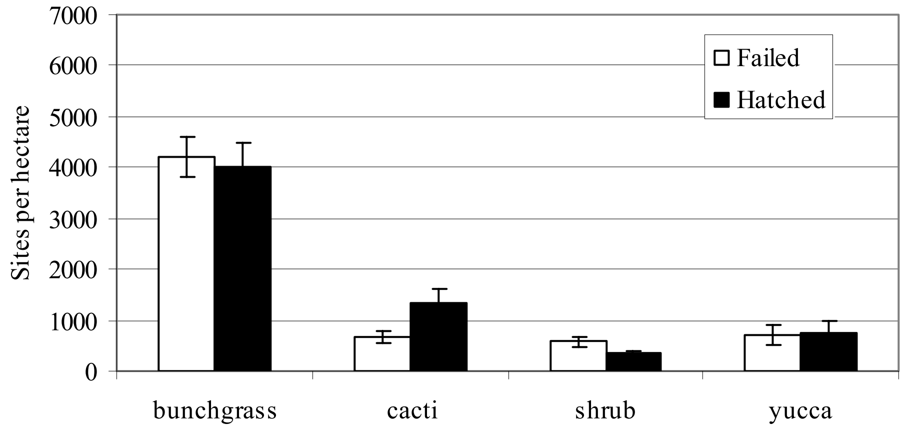

Figure 14. Potential nest sites (sites/ ha) observed within a radius of 40 m of failed and hatched bobwhite nests in Fisher County, Texas, 2003.

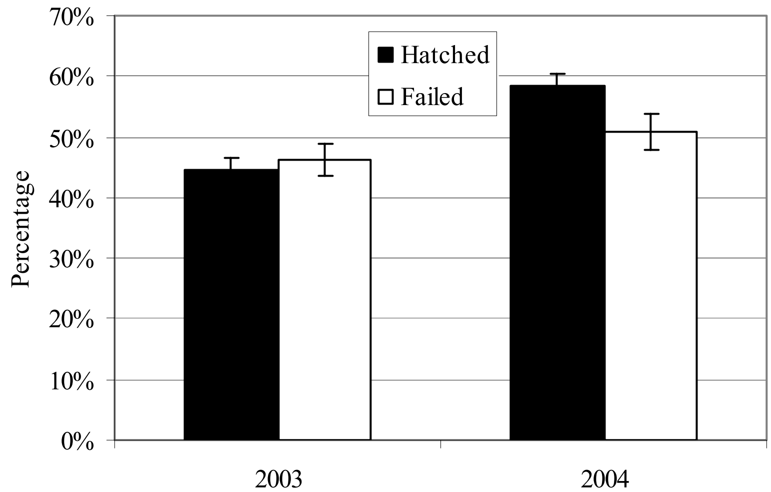

Figure 15. Mean percentage of cover observed within a radius of 40 m of hatched and failed bobwhite nests in Fisher County, Texas, 2003–2004. Means were determined by ocular estimates at 40 points surrounding the nest.

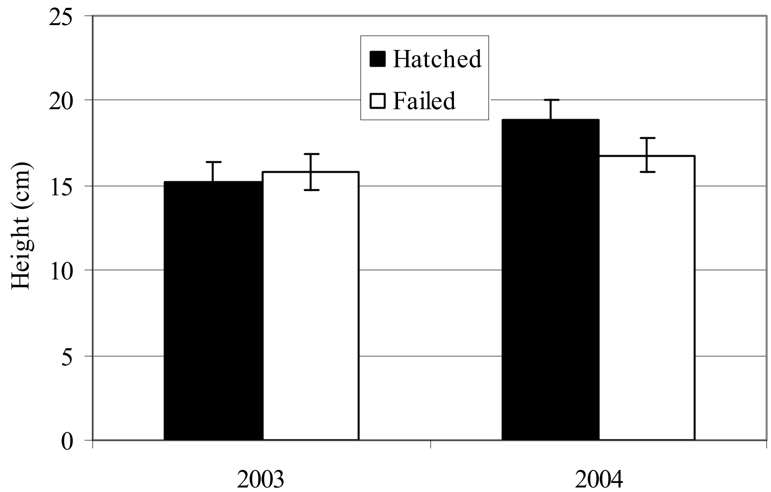

Figure 16. Mean height of vegetation (cm) observed within a radius of 40 m of hatched and failed bobwhite nests in Fisher County, Texas, 2003–2004.

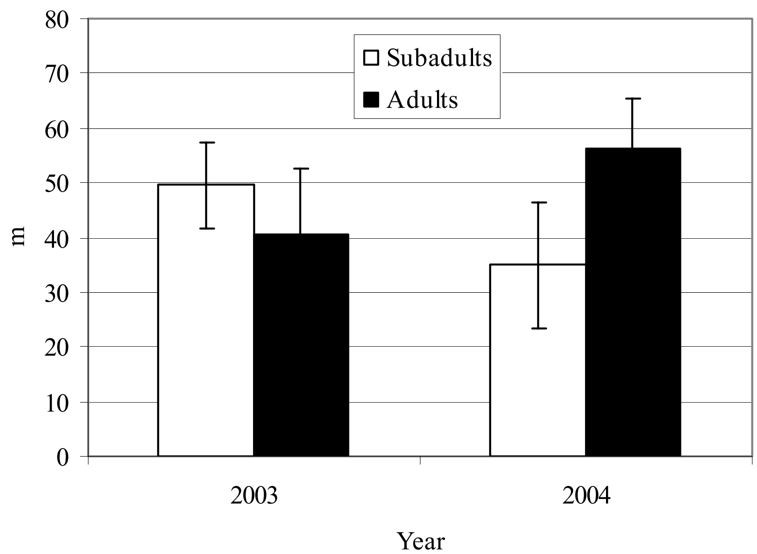

Figure 17. Shortest distance (m) recorded from the nearest road to nests of adult and subadult radiotagged bobwhites in Fisher County, Texas, 2003 – 2004.

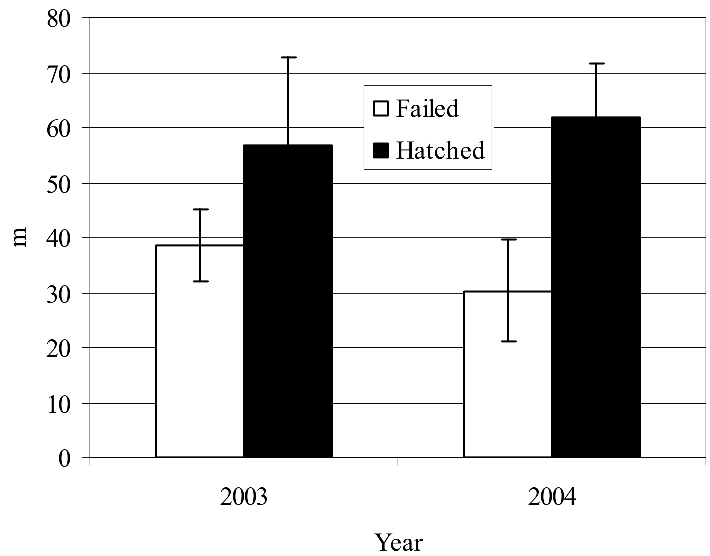

Figure 18. Shortest distance recorded from the nearest road to failed and hatched nests of radiotagged bobwhites in Fisher County, Texas, 2003 – 2004.

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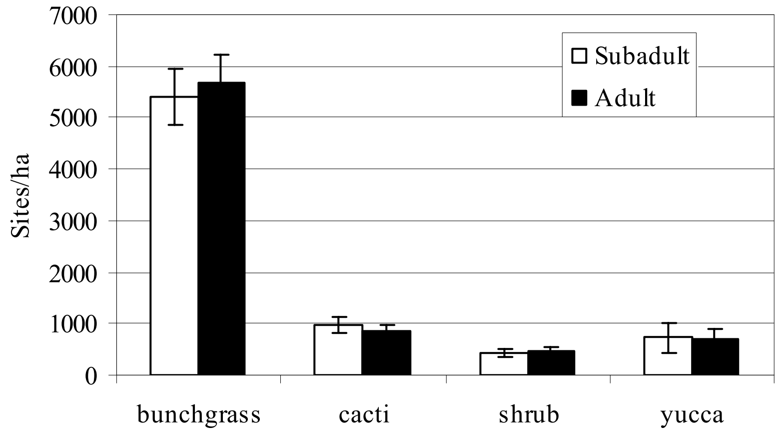

Figure 19. Mean numbers of potential nest sites (sites/ha) surrounding actual nests selected by adult and subadult radiotagged bobwhites in Fisher County, Texas, 2004.

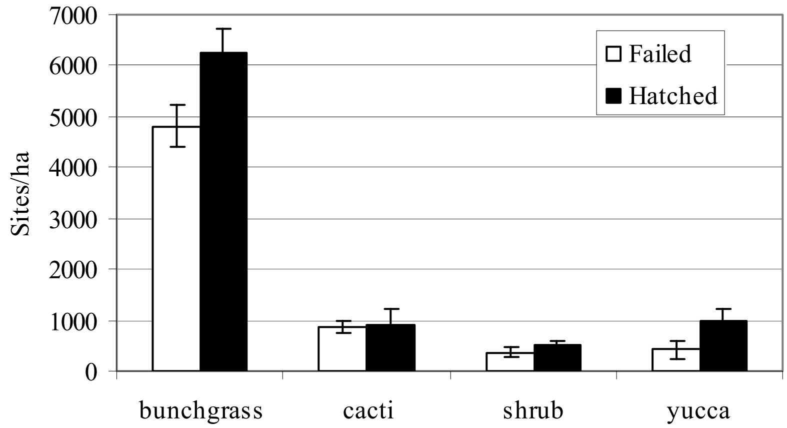

Figure 20. Mean numbers of potential nest sites (sites/ha) surrounding failed and hatched bobwhite nests in Fisher County, Texas, 2004.

Overall demography and nesting

At the beginning of the 2003 and 2004 breeding seasons, the adult:subadult ratios were 1:3.0 and 1:1.3 respectively, based on trap data (Appendices A and B). In the 2 years of this study, 51 females of each age class entered the breeding population, i.e., were alive May 1 (Table 6). Adults produced 200 chicks across both years. Subadults fledged 155 chicks.

Table 6. Estimated production of adult and subadult bobwhites based on age ratios obtained through trapping data and nesting data observed for radiotagged quail in Fisher County, Texas 2003–2004.

Year	Hen Age Class[1]	Initial no. of Hens	No. successful nests	No. live chicks	No. success. nests/hen	No. live chicks/hen	No. hens in population[2]	No. chicks produced	Percent of total chicks
2003	Ad	25	4	39	0.16	1.56	250.0	468.0	16.39
2003	Sub	23	6	61	0.26	2.65	750.0	2406.5	83.61
2004	Ad	26	16	161	0.62	6.19	469.6	3265.5	62.02
2004	Sub	28	8	94	0.29	3.36	530.5	1879.5	37.98

[1]Ad denotes adults. Sub denotes subadults
[2]Calculations assume there are 1000 hens in the population.

DISCUSSION

Nesting season weather conditions

The nesting season of 2003 was hotter and drier than that of 2004. Rainfall totals for July and August 2003 (Table 1) are misleading. All rainfall in July (0.71 cm) occurred prior to July 4, and all August rainfall fell after Aug. 28 (9.63 cm), creating a period of 54 d without rain. The 2004 breeding season was cooler than that of 2003 due to numerous rainfall events throughout the breeding season totaling 40.77 cm. Temperatures in Jul. and Aug. 2004 were considerably cooler than those in Jul. and Aug. 2003 and the long term averages means (Table 7). These differences in weather variables were likely associated with greater nesting success, greater nest site availability, and longer breeding season in 2004 compared to 2003.

Survival

Data from this study failed to reject the null hypothesis of similar rates of breeding season survival among age and sex classes of bobwhite. Age and experience apparently did not provide adult birds any advantage, relative to survival, over subadult birds. Annual survival probabilities of $S = 0.19$ and $S = 0.22$ in 2003 and 2004 respectively were generated using the standardizing feature of Ecological Methodology (Krebs 1999). Radio-tagging may have biased survival estimates low (Guthery and Lusk 2004). Bobwhites banded during 2003 constituted 13% of the sample trapped in 2004. However, 2 of the most productive trap sites of 2003 were not revisited in 2004. This was at my discretion, because of their proximity to power lines, which caused interference with radio telemeters. This move may have limited my ability to catch

Table 7. Average monthly temperatures (ºC) during the bobwhite breeding season as recorded by the National Weather Service in Abilene, Texas. Long-term means (LTM) were calculated since 1885.

	May	Jun	Jul	Aug	Sep
2003	41.45	42.50	46.17	46.23	41.06
2004	40.06	42.78	44.67	43.34	40.67
LTM	40.45	44.34	46.39	45.17	41.95

some individuals that had been banded in 2003, thus the crude annual survival rate of 0.13 was likely biased downward.

It is noteworthy to discuss the body masses that I observed during this study. The means for females (180 – 184 g) was about 15 g heavier than weights typically reported for bobwhites in Texas (Mueller and Dabbert 2002, Table 1). The Aiken Ranch has an intensive supplemental feeding program (free choice feeding of milo) which is operational from early October through early April. Whether the supplemental feeding program was responsible for the heavier body masses, or whether the heavier body masses contributed to either survival or reproductive success relative to unfed populations is unknown.

Cause-specific mortality data from this study were similar to those reported by Carter et al. (2002) and Hernandez (1999). Predation by mammals and raptors are the 2 most common causes of mortality during the breeding season. However, the cache of collars by wood rats created a greater number mortalities attributed to unknown causes. Predation by ground squirrels may be a concern on rangeland as well as when bobwhites are confined in traps (Rosene 1969:160). Predation by rattlesnakes was not a factor in 2003, but was observed 4 times in 2004. This may have been due to radio-failure preventing the discovery of such events in 2003 or increased activity by snakes in the cooler, wetter summer of 2004. Rattlesnakes were not reported as a source of mortality by Hernandez (1999) at a study site in Shackelford County (about 125 km east of my study area). Rattlesnakes have been reported to kill scaled quail (Rollins and

Carroll 2001, Bunty 2004).

Nesting ecology

Data from this study failed to reject the null hypothesis that nest success was similar between adult and subadult bobwhites. Subadults experienced greater nest success than adults in 2003, but no difference was observed between age classes in 2004. This may be attributed to small sample size of nests observed in 2003 (due in part to radio failures).

I also failed to reject the null hypothesis that nesting rates were similar between adult and subadult bobwhites. Adult hens initiated more nests than subadult hens overall, suggesting that adults, while making up a smaller proportion of the bobwhite population (Klimstra and Roseberry 1975), may contribute disproportionately to the overall nesting effort. No differences between nest initiation dates of adult and subadult hens, i. e., the onset of nesting, were detected in this study. Effective length of the breeding season, i.e., time period when nesting activity is actually occurring, may be important in the reproductive effort of bobwhites. The breeding season was >20 days longer in 2004 than in 2003 likely because of the cooler and wetter conditions that prevailed in 2004. This additional time allowed 11 renesting attempts, including those of 2 hens which initiated 3 nests each. In 2003, only 4 renesting attempts were recorded. Hot, dry weather during the summer nesting season depresses nesting activity for bobwhites in Texas (Guthery et al. 1988). The lower temperatures Jul. and Aug. 2004 allowed an extended breeding season compared to 2003.

Guthery and Kuvlesky (1998) used models to identify 3 variables that are necessary for high quail production; (1) the proportion of hens that participate in reproduction, (2) the probability of nest success on any given attempt, and (3) length of the breeding season. My data for 2004 reiterate the importance of length of the breeding season. They also suggest that the adults may make up a greater proportion of the hens attempting to nest at any given time during the breeding season.

Influences of demography

Trapping data revealed a ratio of 1:1.3 adults to juveniles at the beginning of the 2004 breeding season. Ratios this close to 1:1 suggest that increased production by adults might have a substantial impact on recruitment. This was the season in which adults initiated more nests although adults and subadults experienced similar success rates. Projections of annual production suggest that annual variations in the proportion of adult:subadult hens could potentially impact age-specific productivity (Table 7). In 2003, subadults (75% of the breeding population) were responsible for 84% of the production. However in 2004, adults (47% of the breeding population) were responsible for 62% of the production. The increment of production by adult hens, coupled with high adult:subadult ratios, may be a mechanism allowing populations of bobwhites to rebound rapidly (2004) following periods of lower production (2003).

The most notable parameter I observed between adult and subadult hens was that adult hens tend to comprise the bulk of any renesting efforts. Based on Guthery's (2002:74) projections, using a nest success rate of 0.40, chicks produced by second broods could be expected to account for about 30% of the annual production. However chicks hatched later in the summer may contribute somewhat higher contributions to the fall population because they are vulnerable to mortality for a shorter period of time (Guthery 2002:77).

I was unable to detect effects of age on survival or nest success. These data suggest age may improve physiological condition for multiple clutching and/or renesting following failed nest attempts, in years when weather conditions are favorable for quail reproduction. Further research, focusing exclusively on hens to boost sample size, could increase understanding of this phenomena.

Pair bonds

The initial goal of monitoring the pair-bonds and subsequent nesting efficiency of hens and cocks that had paired in 2003 and survived into the 2004 nesting season with that of newly formed pairs was not achieved because none of the paired radiotagged birds I followed survived for the entire study.

Nest site characteristics

Data from this study failed to reject the null hypothesis that nest site selection was similar between adult and subadult bobwhites. Nest site characteristics were not consistent across years or between age classes. Successful nests tended to be located in areas of greater vegetative cover. Potential nest sites surrounding actual nests tended to be higher in 2004 (4500-6500 sites/ha) than 2003 (3500-4500 sites/ha). Hernandez

(1999) concluded increased bunchgrass density was associated with higher nest success in the Rolling Plains of Texas. Amount of prickly pear in the surrounding area was positively associated with nesting success in 2003 but not in 2004, a finding similar to Hernandez (1999). This may have been due to lower availability of bunchgrasses in 2003 or to an artifact of sampling.

Prickly pear comprised 25 and 33% of nests in 2003 and 2004, respectively. I expected the reverse since 2003 was drier than 2004, although the difference in use was small and may be attributed to a small sample size in 2003. Hernandez et al. (2003) speculated that bobwhites may use prickly pear to increase nest protection or in areas with limited bunchgrass availability, i.e., traditional nesting cover. Hernandez et al. (2003) recorded similar use of prickly pear (30% of all nests) in areas with sufficient traditional nesting cover (>1,000 potential nests/ha). Slater et al. (2001) stated that nests in prickly pear survived at greater rates than those in traditional nest sites, i.e., bunchgrasses when suitable bunchgrass sites were < 760/ha.

Texas wintergrass was used as a nesting substrate more than I expected. Texas wintergrass is typically not considered nesting cover for bobwhites. However, in most cases wintergrass was used in association with some other plant species (e.g., prickly pear). Texas wintergrass is generally present in the Edwards Plateau, Rolling Plains, and Cross Timbers regions of Texas (Whisenant et al. 1984). It can provide green foliage year-round, though most production occurs from October through June in years of average rainfall (Whisenant et al. 1984). Winter rainfall was consistent with these requirements during the years of this study (Table 1).

Nests located nearer to roads were more susceptible to predation in 2004 but no difference was detected in 2003. Lehmann (1984:82) and Rosene (1969:63) noted that bobwhites have a tendency to select nest sites in the proximity of roads and trails. However their observations may have been influenced by sampling bias, i.e., nests near roads were easier for observers to find. However, my data, which used radio telemetry to find nests, should have been unbiased relative to nest placement and detection. Data from the Texas Quail Index suggested low abundance of predators at the study site in 2003 and 2004 (D. Rollins, Texas Cooperative Extension, unpublished data). Only 9 visits per 100 scent station nights (SSN) (Sargeant et al. 2003) were recorded in 2003, while 4.5 visits per 100 SSN were recorded in 2004 (1 visitation by a raccoon [*Procyon lotor*]). Raccoons and striped skunks (*Mephitis mephitis*) were the only predators detected by scent stations.

MANAGEMENT IMPLICATIONS AND CONCLUSIONS

Hot, dry summers are commonplace on the western edge of the range of bobwhite quail. These conditions limit the number of available nest sites, the length of the breeding season, directly affect quail nesting success, and affect food availability. In both years of my study, including 1 year with below average rainfall and 1 year with above average rainfall, successful nests tended to be associated with areas of greater vegetative cover. Grazing should be managed to leave a suitable amount of bunchgrass cover. Further research is needed to define thresholds of bunchgrass density to optimize bobwhite production.

During the drier year of this study, 2003, successful nests had more prickly pear in the surrounding area than failed nests. Prickly pear provides shade, structural cover for nests, and obstacles for predators, especially in areas were overgrazing may be a problem. Excessive control of prickly pear may be detrimental to bobwhite reproduction in the Rolling Plains of Texas, especially during dry years. Additional research is warranted to define appropriate thresholds of prickly pear density.

Nests situated near ranch roads suffered higher rates of depredation during this study. Ranch roads and straight brush corridors may serve as travel lanes for quail predators. Research on the effects of edge related to nest success has been inconclusive due to lack of a uniform definition of edge (Paton 1994). Paton’s (1994) review suggested that increased depredation may occur within 50 m of the edge. Reducing the number and frequency of ranch roads may provide fewer common predator corridors and greater nesting success.

My results suggest that adult birds are more productive breeders when considering survival, hatching rate, and nesting rate. The overall contribution of adult production is influenced primarily by the ratio of adults to subadults prior to the breeding season. Curtailing harvest of quail during years following lower than normal reproduction would allow a greater number of adult hens to enter the breeding season. As age ratios approach 1:1 (as might be encountered following below-average rainfall years), managers should limit or halt quail harvest. Keeping harvest records including age and sex of each bird harvested will facilitate management decisions.

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APPENDIX A.

Individual records for radiotagged bobwhites in Fisher County, Texas 2003-2004.

Frequency	Band no.	Sex	Age	Weight	Trap site	Date in	Date out	Fate
151.027	1211	F	A	170	W	03/01/03	04/14/03	mammalian mortality
151.039	1225	F	A	190	S	3/10/2004	05/17/04	mammalian mortality
150.874	1243	F	A	180	W	03/01/03	N/A	N/A
150.036	1244	F	A	175	S	03/06/03	04/28/03	mortality unknown
150.816	1249	F	A	185	NE	03/06/03	N/A	N/A
150.454	1256	F	A	190	NE	03/05/03	N/A	N/A
150.755	1261	F	A	170	WM	03/10/03	N/A	N/A
150.353	1263	F	A	175	S	03/07/03	N/A	N/A
150.375	1278	F	A	165	S	03/11/03	N/A	N/A
151.345	1286	F	A	170	C	03/11/03	06/06/03	mammalian mortality
150.697	1300	F	A	180	C	3/11/2003	01/05/04	mammalian mortality
150.025	1300	F	A	190	C	03/11/03	N/A	N/A
151.585	1338	F	A	190	FP	03/12/03	N/A	N/A
151.645	1345	F	A	170	C	03/12/03	N/A	N/A
151.425	1351	F	A	200	S	03/12/03	N/A	N/A
150.809	1354	F	A	180	C	03/12/03	08/04/03	avian mortality
151.465	1358	F	A	190	S	03/13/03	N/A	N/A
151.112	1381	F	A	175	C	3/16/2004	05/10/04	mammalian mortality
151.125	1388	F	A	170	FP	03/17/03	N/A	N/A
151.875	1389	F	A	195	S	03/17/03	N/A	N/A
150.526	1604	F	A	170	WC	2/26/2004	N/A	N/A
151.096	1620	F	A	185	W	03/18/03	N/A	N/A
151.020	1637	F	A	185	S	03/18/03	N/A	unknown WRM
151.194	1639	F	A	200	WC	03/18/03	N/A	mammalian mortality
151.564	1640	F	A	175	WC	03/18/03	07/04/03	mortality unknown
150.635	1651	F	A	185	WC	03/19/03	N/A	N/A
150.950	1665	F	A	180	FP	3/15/2004	N/A	N/A
150.415	1700	F	A	205	LC	03/21/03	N/A	N/A

151.176	1701	F	A	205	WT	03/25/03	04/18/03	avian mortality
150.145	1711	F	A	205	LC	03/25/03	07/04/03	mortality unknown
151.024	1736	F	A	175	WT	03/27/03	N/A	N/A
150.045	1754	F	A	170	BC	03/27/03	04/16/03	slipped collar
151.935	1759	F	A	195	LC	03/31/03	05/30/03	unknown WRM[1]
151.678	1774	F	A	190	JY	1/16/2004	01/29/04	slipped collar
151.652	1775	F	A	210	JY	1/16/2004	03/29/04	mammalian mortality
150.944	1839	F	A	190	4W	04/09/03	05/05/03	unknown WRM
150.056	1863	F	A	180	C	8/20/2003	11/07/03	mortality unknown
150.176	1876	F	A	180	BC	9/10/2003	09/29/03	N/A
150.875	1882	F	A	180	BC	9/10/2003	N/A	N/A
151.696	1888	F	A	195	NE	1/6/2003	N/A	N/A
150.595	2003	F	A	185	LC	1/14/2004	03/20/04	lost signal
151.409	2028	F	A	185	FP	1/14/2004	N/A	N/A
151.265	2033	F	A	185	JY	1/16/2004	05/25/04	mammalian mortality
151.444	2038	F	A	180	FP	1/14/2004	01/20/04	avian mortality
151.662	2043	F	A	190	JY	1/16/2004	05/03/04	avian mortality
151.453	2045	F	A	200	JY	1/16/2004	02/02/04	slipped collar
151.608	2050	F	A	185	NE	1/17/2004	N/A	N/A
151.642	2051	F	A	190	WC	1/16/2004	N/A	N/A
151.678	2057	F	A	180	DR	2/26/2004	03/31/04	avian mortality
151.320	2059	F	A	190	DR	2/26/2004	N/A	N/A
150.318	2063	F	A	180	WC	2/26/2004	04/08/04	unknown WRM
150.473	2064	F	A	190	NE	2/26/2004	07/05/04	avian mortality
151.527	2065	F	A	190	S	2/26/2004	05/03/04	mortality unknown
150.392	2067	F	A	180	NE	2/26/2004	N/A	N/A
150.508	2070	F	A	180	FP	2/26/2004	04/06/04	unknown WRM
150.761	2071	F	A	180	DR	3/2/2004	N/A	N/A
151.338	2073	F	A	175	WC	2/26/2004	07/28/04	rattlesnake mortality
150.644	2076	F	A	175	WC	2/26/2004	N/A	N/A
150.975	2126	F	A	160	S	3/9/2004	N/A	N/A
151.129	2140	F	A	190	WC	3/11/2004	05/03/04	avian mortality
150.897	2144	F	A	155	FP	3/15/2004	07/16/04	rattlesnake mortality
151.146	2150	F	A	170	C	3/16/2004	N/A	N/A

150.959	2153	F	A	185	NE	3/15/2004	N/A	N/A
150.546	2171	F	A	200	C	4/14/2004	N/A	N/A
150.204	2184	F	A	215	C	4/14/2004	N/A	N/A
151.926	N/A	F	A	175	C	03/18/03	N/A	N/A
150.771	N/A	F	A	190	C	4/14/2004	N/A	N/A
151.695	1208	M	A	200	W	2/28/03	08/22/03	mortality unknown
150.800	1208	M	A	200	W	02/28/03	N/A	N/A
151.400	1209	M	A	190	S	02/28/03	N/A	N/A
150.936	1230	M	A	180	W	03/05/03	N/A	N/A
150.295	1230	M	A	180	W	3/1/03	N/A	N/A
151.696	1232	M	A	185	NE	03/05/03	N/A	N/A
150.075	1236	M	A	180	S	03/05/03	04/24/03	mortality unknown
150.575	1252	M	A	175	S	03/06/03	N/A	N/A
150.495	1255	M	A	175	NE	03/07/03		avian mortality
150.007	1265	M	A	180	WM	03/10/03	N/A	mortality unknown
150.434	1268	M	A	185	S	03/10/03	N/A	mortality unknown
151.312	1269	M	A	190	NE	3/19/2004	N/A	lost signal
150.776	1274	M	A	170	W	03/10/03	04/30/03	exposure
150.166	1285	M	A	185	C	03/11/03	N/A	N/A
151.943	1298	M	A	185	S	03/11/03	N/A	N/A
151.517	1322	M	A	170	S	2/26/2004	04/21/04	unknown WRM
151.015	1337	M	A	185	C	03/12/03	N/A	N/A
151.285	1339	M	A	175	BC	03/12/03	06/11/03	mammalian mortality
150.357	1341	M	A	195	WC	2/26/2004	05/17/04	mammalian mortality
151.225	1349	M	A	180	C	03/12/03	N/A	N/A
151.035	1350	M	A	170	C	03/12/03	06/30/03	avian mortality
151.066	1357	M	A	170	S	3/10/2004	04/23/04	mammalian mortality
151.685	1357	M	A	185	S	03/13/03	N/A	N/A
151.335	1363	M	A	200	NE	03/13/03	N/A	N/A
151.726	1364	M	A	185	NE	03/17/03	N/A	N/A
150.315	1376	M	A	185	BC	03/17/03	N/A	N/A
150.715	1376	M	A	185	BC	3/17/03	N/A	N/A
150.476	1378	M	A	175	S	03/17/03	07/15/03	mammalian mortality
151.046	1397	M	A	185	C	03/17/03	N/A	N/A

150.902	1612	M	A	195	FP	03/18/03	05/12/03	slipped collar
150.599	1612	M	A	195	FP	2/26/2004	N/A	N/A
150.984	1671	M	A	205	FP	3/15/2004	N/A	N/A
150.635	1676	M	A	170	WC	2/26/2004	N/A	N/A
150.508	1703	M	A	190	C	4/14/2004	06/28/04	N/A
151.056	1715	M	A	175	LC	03/25/03	N/A	N/A
151.671	1717	M	A	220	WC	1/16/2004	01/29/04	mortality unknown
150.651	1717	M	A	NW	RT	4/5/2004	N/A	N/A
150.085	1751	M	A	185	WT	03/27/03	04/22/03	mammalian mortality
151.116	1771	M	A	185	BC	03/27/03	N/A	N/A
151.246	1771	M	A	185	BC	3/27/03	N/A	N/A
151.636	1781	M	A	230	JY	1/16/2004	06/10/04	mortality unknown
150.913	1782	M	A	180	C	3/9/2004	05/17/04	mammalian mortality
150.065	1783	M	A	165	C	03/27/03	N/A	N/A
151.244	1795	M	A	185	LC	03/25/03	N/A	N/A
150.615	1838	M	A	185	4W	04/09/03	05/02/03	avian mortality
150.884	1856	M	A	180	C	8/20/2003	N/A	N/A
151.410	1858	M	A	NW	NE	04/09/03	N/A	N/A
151.473	1871	M	A	185	BC	9/10/2003	03/26/04	mortality unknown
151.210	2025	M	A	190	JY	1/16/2004	04/07/04	unknown WRM
151.372	2040	M	A	215	FP	1/14/2004	N/A	N/A
151.616	2042	M	A	180	JY	1/16/2004	02/02/04	slipped collar
151.380	2044	M	A	190	JY	2/16/2004	N/A	N/A
151.229	2046	M	A	210	C	1/16/2004	N/A	N/A
151.409	2052	M	A	175	S	2/16/2004	N/A	N/A
151.275	2055	M	A	205	NE	2/16/2004	N/A	N/A
151.437	2056	M	A	210	NE	1/17/2004	04/07/04	avian mortality
151.444	2058	M	A	180	DR	2/26/2004	N/A	N/A
151.511	2069	M	A	190	S	2/26/2004	N/A	N/A
150.586	2072	M	A	180	FP	2/26/2004	N/A	N/A
150.771	2097	M	A	180	DR	3/2/2004	04/08/04	unknown WRM
150.659	2100	M	A	180	WC	2/27/2004	N/A	N/A
150.905	2109	M	A	180	DR	3/9/2004	N/A	N/A
150.932	2110	M	A	185	C	3/9/2004	N/A	N/A

150.921	2124	M	A	210	S	3/9/2004	N/A	N/A
150.940	2132	M	A	200	WT	3/11/2004	N/A	N/A
151.158	2142	M	A	170	C	3/16/2004	04/28/04	mammalian mortality
150.860	2161	M	A	190	WC	3/15/2004	N/A	N/A
151.652	2177	M	A	180	RT	3/30/2004	N/A	N/A
150.615	N/A	M	A	190	WM	03/10/03	04/09/03	mammalian mortality
150.875	N/A	M	A	175	S	03/11/03	N/A	N/A
151.495	1206	F	J	200	S	02/28/03	05/30/03	mortality WRM
150.809	1210	F	J	170	WP	03/01/03	05/12/03	mammalian mortality
151.250	1215	F	J	190	WP	03/01/03	05/23/03	mortality WRM
151.133	1217	F	J	185	WP	03/05/03	08/01/03	slipped collar
150.196	1219	F	J	170	NE	03/01/03	N/A	N/A
150.395	1227	F	J	200	S	03/01/03	06/30/03	avian mortality
150.055	1238	F	J	205	NE	03/05/03	N/A	N/A
150.596	1238	F	J	190	NE	03/01/03	N/A	N/A
151.194	1242	F	J	210	W	3/1/03	01/07/04	harvest
150.911	1242	F	J	210	W	03/01/03	N/A	N/A
150.135	1247	F	J	190	NE	03/06/03	N/A	N/A
150.655	1253	F	J	165	WM	03/10/03	N/A	N/A
150.535	1257	F	J	165	W	03/07/03	06/04/03	slipped collar
150.296	1258	F	J	150	WM	03/10/03	N/A	N/A
150.675	1264	F	J	180	WM	03/10/03	N/A	N/A
150.876	1275	F	J	185	NE	03/11/03	N/A	N/A
150.736	1279	F	J	175	S	03/11/03	06/30/03	unknown WRM
150.306	1281	F	J	170	C	03/11/03	06/19/03	slipped collar
151.476	1282	F	J	160	C	03/11/03	06/18/03	exposure
151.085	1296	F	J	175	C	3/11/03	10/15/03	mortality unknown
150.275	1296	F	J	175	C	03/11/03	N/A	N/A
151.733	1297	F	J	190	S	03/12/03	N/A	N/A
151.065	1324	F	J	175	BC	03/12/03	N/A	N/A
151.005	1324	F	J	175	BC	3/12/03	N/A	N/A
151.775	1329	F	J	185	BC	03/12/03	N/A	avian mortality
151.376	1336	F	J	175	BC	03/12/03	N/A	N/A
151.275	1352	F	J	175	C	03/12/03	N/A	N/A

151.250	1368	F	J	175	NE	03/17/03	06/06/03	unknown WRM
151.410	1643	F	J	200	WP	03/19/03	N/A	unknown WRM
150.495	1650	F	J	195	DR	03/19/03	N/A	N/A
151.515	1675	F	J	185	WT	03/25/03	N/A	N/A
150.434	1687	F	J	185	WT	03/21/03	06/06/03	mammalian mortality
151.775	1702	F	J	190	WT	03/25/03	N/A	N/A
150.536	1857	F	J	205	BC	04/09/03	N/A	N/A
150.036	1857	F	J	215	BC	8/20/2003	N/A	N/A
151.463	1860	F	J	205	BC	8/20/2003	06/01/04	avian mortality
150.045	1860	F	J	215	BC	04/09/03	N/A	N/A
151.499	1865	F	J	NW	BC	8/20/2003	07/14/04	mortality unknown
150.945	1868	F	J	195	BC	8/20/2003	01/14/04	avian mortality
150.555	1869	F	J	175	BC	9/10/2003	N/A	N/A
150.096	1870	F	J	175	BC	08/20/03	12/06/03	harvest
151.483	1874	F	J	NW	BC	8/20/2003	03/22/04	exposure
151.124	1886	F	J	185	C	3/11/2003	04/28/04	lost signal
151.312	2006	F	J	200	NE	1/12/2004	N/A	N/A
151.678	2010	F	J	170	WC	1/12/2004	N/A	N/A
151.302	2011	F	J	180	NE	1/12/2004	03/19/04	unknown WRM
151.632	2012	F	J	165	WC	1/12/2004	N/A	N/A
151.238	2014	F	J	190	S	1/14/2004	N/A	N/A
151.329	2016	F	J	180	NE	1/12/2004	04/16/04	slipped collar
151.292	2017	F	J	185	NE	1/12/2004	01/20/04	slipped collar
151.222	2023	F	J	205	JY	1/16/2004	05/10/04	mammalian mortality
151.399	2027	F	J	185	WC	1/14/2004	05/18/04	mammalian mortality
151.596	2035	F	J	185	S	1/14/2004	06/03/04	mortality unknown
151.437	2037	F	J	190	S	1/14/2004	01/16/04	slipped collar
151.428	2039	F	J	170	FP	1/14/2004	07/06/04	avian mortality
151.554	2049	F	J	180	S	2/26/2004	N/A	N/A
151.292	2054	F	J	175	DR	2/26/2004	05/19/04	rattlesnake mortality
150.804	2080	F	J	175	DR	3/8/2004	07/05/04	exposure
151.652	2081	F	J	180	W	3/5/2004	N/A	N/A
150.680	2092	F	J	175	WC	3/2/2004	N/A	N/A
150.795	2093	F	J	160	DR	3/2/2004	07/08/04	rattlesnake mortality

150.671	2098	F	J	170	WC	3/2/2004	N/A	N/A
150.787	2099	F	J	170	DR	3/8/2004	05/25/04	mammalian mortality
150.815	2107	F	J	170	S	3/9/2004	N/A	N/A
151.121	2114	F	J	180	S	3/10/2004	05/06/04	avian mortality
151.483	2170	F	J	185	C	4/5/2004	N/A	N/A
151.507	2188	F	J	180	FP	3/19/2004	N/A	N/A
151.031	2197	F	J	NW	C	4/5/2004	N/A	N/A
150.415	N/A	F	J	175	NE	03/10/03	N/A	N/A
151.283	N/A	F	J	195	NE	1/12/2004	N/A	N/A
151.070	1203	M	J	190	WP	02/28/03	06/05/03	avian mortality
151.081	1207	M	J	195	S	03/01/03	05/23/03	avian mortality
151.650	1212	M	J	185	WP	03/01/03	N/A	N/A
151.640	1213	M	J	185	WP	03/01/03		avian mortality
151.110	1216	M	J	185	WP	03/01/03	06/30/03	slipped collar
150.215	1218	M	J	185	S	03/01/03	N/A	N/A
150.096	1226	M	J	185	NE	03/05/03	04/18/03	mammalian mortality
150.928	1231	M	J	170	W	03/05/03	04/16/03	collar slipped
150.335	1245	M	J	185	NE	03/01/03	08/01/03	mammalian mortality
150.115	1246	M	J	170	W	03/06/03	N/A	N/A
150.256	1248	M	J	180	W	03/06/03	N/A	N/A
150.555	1251	M	J	165	NE	03/06/03	N/A	N/A
150.156	1260	M	J	180	W	03/11/03	05/01/03	slipped collar
150.156	1260	M	J	180	W	3/5/03	N/A	N/A
150.175	1267	M	J	185	S	03/10/03	05/23/03	mammalian mortality
150.235	1267	M	J	180	NE	03/10/03	N/A	N/A
150.695	1270	M	J	175	NE	03/10/03	N/A	mortality WRM
150.715	1272	M	J	170	WM	03/10/03	N/A	N/A
150.916	1291	M	J	165	NE	03/11/03	05/27/03	slipped collar
151.685	1292	M	J	170	C	03/11/03	07/16/03	mammalian mortality
150.086	1293	M	J	190	C	03/11/03	N/A	N/A
150.187	1323	M	J	185	S	03/12/03	N/A	N/A
151.144	1327	M	J	185	S	03/12/03	N/A	N/A
151.805	1334	M	J	165	S	03/12/03	N/A	N/A
151.835	1335	M	J	175	BC	03/12/03	N/A	N/A

151.754	1346	M	J	175	C	03/12/03	08/04/03	mammalian mortality
151.515	1359	M	J	175	C	03/17/03	N/A	mammalian mortality
150.536	1365	M	J	195	S	03/17/03	04/24/03	mortality WRM
150.175	1379	M	J	170	NE	03/17/03	N/A	N/A
150.615	1379	M	J	170	NE	5/28/03	N/A	N/A
150.125	1610	M	J	170	S	03/18/03	05/27/03	mammalian mortality
150.036	1644	M	J	175	DR	03/19/03	N/A	unknown WRM
150.165	1673	M	J	165	S	03/20/03	05/19/03	mortality WRM
150.007	1703	M	J	180	WT	03/25/03	N/A	N/A
150.135	1703	M	J	180	WT	3/25/03	N/A	N/A
150.695	1704	M	J	195	S	03/25/03	N/A	N/A
150.015	1773	M	J	185	WT	03/27/03	N/A	N/A
150.776	1856	M	J	180	WT	04/09/03	N/A	N/A
150.916	1862	M	J	NW	NE	04/09/03	N/A	N/A
151.580	1866	M	J	NW	BC	8/20/2003	05/17/04	mammalian mortality
151.507	1872	M	J	NW	BC	9/10/2003	03/19/04	overnight mortality
150.517	1877	M	J	180	LC	12/15/2003	02/28/04	lost signal
150.435	1879	M	J	190	WC	12/10/2003	01/16/04	unknown WRM
150.845	1883	M	J	180	WC	9/10/2003	N/A	N/A
151.107	1887	M	J	180	WC	12/10/2003	N/A	N/A
150.945	2002	M	J	195	S	1/14/2004	N/A	N/A
151.605	2015	M	J	190	S	1/12/2004	01/23/04	mortality unknown
150.265	2020	M	J	180	S	1/14/2004	N/A	N/A
151.320	2021	M	J	170	LC	1/14/2004	01/20/04	mortality unknown
151.338	2022	M	J	180	S	1/14/2004	01/29/04	slipped collar
151.587	2024	M	J	180	S	1/14/2004	N/A	N/A
151.275	2026	M	J	200	S	1/14/2004	N/A	N/A
151.391	2030	M	J	190	FP	1/14/2004	03/05/04	mortality unknown
151.380	2031	M	J	175	FP	1/14/2004	01/26/04	slipped collar
151.572	2032	M	J	180	W	3/9/2004	N/A	N/A
151.418	2034	M	J	180	FP	1/14/2004	04/22/04	mammalian mortality
151.489	2036	M	J	190	S	1/14/2004	N/A	N/A
151.688	2041	M	J	185	JY	1/16/2004	N/A	N/A
150.699	2048	M	J	180	S	2/16/2004	N/A	N/A

151.623	2053	M	J	190	WC	1/16/2004	03/31/04	unknown WRM
150.490	2062	M	J	185	NE	2/26/2004	N/A	N/A
151.453	2074	M	J	185	NE	2/26/2004	N/A	N/A
150.235	2075	M	J	NW	DR	4/14/2004	N/A	N/A
151.354	2077	M	J	160	WC	3/10/2004	N/A	N/A
150.651	2079	M	J	180	FP	3/8/2004	03/29/04	mortality unknown
151.347	2106	M	J	180	S	3/9/2004	N/A	N/A
151.362	2116	M	J	190	W	3/9/2004	03/19/04	mortality unknown
151.047	2128	M	J	170	S	3/10/2004	N/A	N/A
151.020	2129	M	J	180	W	3/11/2004	N/A	N/A
150.833	2133	M	J	175	S	3/16/2004	05/10/04	mortality unknown
151.139	2135	M	J	175	FP	3/19/2004	N/A	N/A
150.967	2138	M	J	170	FP	3/15/2004	03/29/04	mortality unknown
151.476	2172	M	J	175	RT	4/14/2004	N/A	N/A
150.967	2183	M	J	175	C	4/5/2004	04/28/04	avian mortality
150.824	2194	M	J	170	BC	3/19/2004	N/A	N/A
150.884	2196	M	J	180	BC	3/19/2004	04/06/04	unknown WRM
151.362	2198	M	J	NW	C	4/5/2004	N/A	N/A
151.037	N/A	M	J	180	WC	12/17/2003	03/31/04	slipped collar

[1]WRM denotes the radio-collar was found in a southern plains wood rat midden.

APPENDIX B.

Individual banding records for bobwhites in Fisher County, Texas 2003-2004

Band no.	Sex	Age	Weight	Location	Date In
1225	F	A	190	WP	03/05/03
1241	F	A	190	WP	03/05/03
1266	F	A	190	S	03/07/03
1372	F	A	185	DR	03/17/03
1658	F	A	170	W	03/20/03
1661	F	A	170	W	03/21/03
1668	F	A	175	S	03/21/03
1685	F	A	NW	SR	03/22/03
1689	F	A	NW	WC	03/22/03
1694	F	A	185	WC	02/27/04
1719	F	A	180	SR	03/25/03
1739	F	A	190	RF	03/26/03
1755	F	A	180	SR	03/09/04
1774	F	A	185	JY	03/31/03
1775	F	A	210	JY	03/31/03
1780	F	A	175	C	04/01/03
1786	F	A	170	FT	04/01/03
1792	F	A	175	FT	04/01/03
1798	F	A	165	FT	04/01/03
1813	F	A	180	BH	04/08/03
1814	F	A	200	4W	04/08/03
1841	F	A	200	BH	04/09/03
1842	F	A	200	WT	04/09/03
1850	F	A	190	PP	04/09/03
1851	F	A	185	PP	04/09/03
1882	F	A	175	BC	10/02/03
1889	F	A	195	WP	01/12/04
2008	F	A	185	WP	01/12/04
2013	F	A	180	WP	01/12/04

2018	F	A	200	WP	01/12/04
2094	F	A	185	WC	02/27/04
2105	F	A	185	SR	03/10/04
2108	F	A	205	SR	03/10/04
2127	F	A	170	SR	03/10/04
2130	F	A	175	RT	03/16/04
2158	F	A	185	RT	03/16/04
2168	F	A	170	C	03/19/04
2174	F	A	180	OB	03/24/04
2175	F	A	200	C	04/14/04
2192	F	A	180	NE	03/19/04
1869	F	N/A	160	BC	09/09/03
1202	F	J	190	NE	02/28/03
1214	F	J	190	NE	02/28/03
1219	F	J	185	NE	03/01/03
1222	F	J	185	NE	03/01/03
1228	F	J	190	WP	03/05/03
1234	F	J	185	WP	03/05/03
1237	F	J	205	WP	03/05/03
1240	F	J	185	S	03/01/03
1254	F	J	195	WP	03/06/03
1259	F	J	185	S	03/05/03
1271	F	J	170	BC	03/11/03
1279	F	J	165	S	03/07/03
1280	F	J	185	BC	03/11/03
1287	F	J	170	S	03/11/03
1294	F	J	185	S	03/11/03
1295	F	J	190	C	03/11/03
1325	F	J	175	FP	03/12/03
1330	F	J	170	FP	03/12/03
1332	F	J	170	FP	03/12/03
1343	F	J	170	C	03/12/03
1353	F	J	170	C	03/13/04
1356	F	J	185	NE	03/13/04

1361	F	J	175	BC	03/13/04
1362	F	J	185	S	03/13/04
1366	F	J	175	WC	03/17/03
1369	F	J	170	BC	03/13/03
1371	F	J	175	WC	03/17/03
1374	F	J	175	WC	03/17/03
1381	F	J	165	C	03/17/03
1386	F	J	170	NE	03/17/03
1390	F	J	175	FP	03/17/03
1391	F	J	165	C	03/18/03
1393	F	J	200	S	03/18/03
1398	F	J	175	S	03/17/03
1399	F	J	170	S	03/17/04
1603	F	J	160	FP	03/18/03
1604	F	J	170	WC	03/18/03
1605	F	J	170	FP	03/18/03
1607	F	J	185	S	03/18/03
1611	F	J	185	DR	03/18/03
1614	F	J	160	S	03/18/03
1618	F	J	200	WP	03/19/03
1619	F	J	180	W	03/19/03
1622	F	J	175	DR	03/18/03
1623	F	J	180	W	03/19/03
1627	F	J	180	W	03/19/03
1630	F	J	185	W	03/19/03
1633	F	J	200	W	03/19/03
1638	F	J	180	W	03/20/03
1645	F	J	190	WP	03/20/03
1646	F	J	175	WC	03/20/03
1647	F	J	190	WP	03/20/03
1652	F	J	175	WC	03/19/03
1655	F	J	180	WP	03/20/03
1662	F	J	150	W	03/21/03
1663	F	J	190	W	03/21/03

1665	F	J	185	W	03/21/03
1666	F	J	170	S	03/20/03
1667	F	J	195	W	03/21/03
1672	F	J	170	W	03/21/03
1674	F	J	165	FP	03/21/03
1679	F	J	180	WT	03/22/03
1681	F	J	NW	DR	03/22/03
1682	F	J	NW	RF	03/22/03
1686	F	J	NW	DR	03/22/03
1690	F	J	180	WC	03/22/03
1692	F	J	185	FP	03/22/03
1694	F	J	195	WC	03/24/03
1699	F	J	180	RF	03/25/03
1705	F	J	190	S	03/25/03
1706	F	J	185	FT	03/25/03
1709	F	J	160	LC	03/25/03
1712	F	J	170	LC	03/25/03
1720	F	J	165	LC	03/26/03
1722	F	J	185	FT	03/25/03
1724	F	J	190	SR	03/25/03
1725	F	J	190	FT	03/25/03
1726	F	J	205	FT	03/25/03
1727	F	J	185	SR	03/25/03
1729	F	J	175	FT	03/25/03
1731	F	J	190	SR	03/25/03
1732	F	J	190	FT	03/25/03
1733	F	J	200	FT	03/25/03
1735	F	J	175	FT	03/25/03
1736	F	J	190	FT	03/26/03
1737	F	J	170	SR	03/26/03
1740	F	J	200	SR	03/26/03
1741	F	J	170	SR	03/26/03
1742	F	J	190	FT	03/26/03
1744	F	J	160	SR	03/26/03

1747	F	J	180	FT	03/26/03
1750	F	J	NW	SR	03/26/03
1755	F	J	175	SR	03/26/03
1756	F	J	175	BC	03/27/03
1757	F	J	180	SR	03/27/03
1758	F	J	190	S	03/26/03
1761	F	J	185	WT	03/27/03
1762	F	J	NW	SR	03/26/03
1766	F	J	190	FT	03/26/03
1767	F	J	200	JY	03/26/03
1768	F	J	190	SR	03/27/03
1770	F	J	185	LC	03/31/03
1777	F	J	200	LC	03/31/03
1787	F	J	180	FT	04/01/03
1790	F	J	180	FT	04/01/03
1793	F	J	175	LC	04/01/03
1797	F	J	170	S	04/01/03
1799	F	J	190	BC	04/07/03
1800	F	J	180	SD	04/08/03
1822	F	J	190	BH	04/08/03
1825	F	J	210	BH	04/09/03
1826	F	J	165	BH	04/09/03
1828	F	J	205	SD	04/09/03
1830	F	J	195	SD	04/09/03
1832	F	J	180	SD	04/09/03
1835	F	J	200	4W	04/09/03
1837	F	J	185	JY	04/09/03
1844	F	J	180	BH	04/09/03
1845	F	J	190	BH	04/09/03
1846	F	J	190	BH	04/09/03
1848	F	J	190	BH	04/09/03
1849	F	J	185	BH	04/09/03
1864	F	J	160	BC	08/20/03
1866	F	J	145	BC	08/20/03

1873	F	J	155	BC	08/20/03
1874	F	J	145	BC	08/20/03
1878	F	J	195	WP	01/12/04
1890	F	J	180	WP	01/06/04
1892	F	J	215	WP	01/06/04
1894	F	J	180	WP	01/06/04
2009	F	J	175	WP	01/12/04
2019	F	J	190	NE	01/12/04
2068	F	J	190	S	02/26/04
2083	F	J	180	W	03/08/04
2085	F	J	180	W	03/08/04
2089	F	J	180	W	03/08/04
2090	F	J	195	WC	02/27/04
2091	F	J	180	W	03/08/04
2102	F	J	NW	W	03/09/04
2104	F	J	NW	W	03/09/04
2112	F	J	175	S	03/10/04
2115	F	J	180	S	03/10/04
2121	F	J	180	S	03/10/04
2125	F	J	NW	W	03/09/04
2134	F	J	175	FP	03/15/04
2136	F	J	180	S	03/16/04
2137	F	J	165	C	03/16/04
2141	F	J	170	FP	03/15/04
2145	F	J	NW	WM	03/16/04
2147	F	J	180	W	03/11/04
2148	F	J	185	WT	03/11/04
2149	F	J	180	W	03/15/04
2152	F	J	175	S	03/16/04
2154	F	J	180	FP	03/15/04
2156	F	J	180	S	03/16/04
2162	F	J	185	NE	03/19/04
2165	F	J	175	W	03/15/04
2166	F	J	175	FP	03/15/04

2179	F	J	180	RT	04/14/04
2199	F	J	160	C	03/19/04
1204	M	A	205	WP	02/28/03
1226	M	A	200	NE	03/05/03
1239	M	A	180	S	03/01/03
1341	M	A	185	WC	03/12/03
1377	M	A	180	DR	03/17/03
1648	M	A	200	WP	03/20/03
1656	M	A	145	W	03/20/03
1659	M	A	180	S	03/20/03
1660	M	A	165	W	03/21/03
1676	M	A	190	WC	01/16/04
1678	M	A	190	LC	03/22/03
1680	M	A	190	WC	02/26/04
1684	M	A	NW	SR	03/22/03
1696	M	A	NW	FT	03/22/04
1713	M	A	180	FT	03/25/03
1718	M	A	NW	SR	03/09/04
1749	M	A	NW	SR	03/09/04
1752	M	A	185	SR	03/26/03
1753	M	A	175	SR	03/26/03
1763	M	A	165	SR	03/26/03
1765	M	A	180	SR	03/26/03
1796	M	A	170	LC	04/01/03
1808	M	A	170	BH	04/08/03
1834	M	A	175	4W	04/09/03
1852	M	A	180	PP	04/09/03
1853	M	A	175	PP	04/09/03
1875	M	A	200	WP	01/06/04
1884	M	A	180	WC	09/09/03
1893	M	A	180	WP	01/06/04
1900	M	A	180	WP	01/12/04
2007	M	A	200	WP	01/12/04
2029	M	A	190	WP	01/14/04

2101	M	A	200	W	03/09/04
2118	M	A	NW	SR	03/09/04
2120	M	A	185	SR	03/10/04
2122	M	A	180	SR	03/09/04
2131	M	A	1885	NE	03/16/04
2159	M	A	185	RT	03/16/04
2160	M	A	175	BC	03/16/04
2169	M	A	200	C	04/14/04
2178	M	A	180	OB	03/24/04
2180	M	A	180	RT	03/26/04
2181	M	A	185	RT	04/14/04
2185	M	A	185	SR	03/24/04
2189	M	A	NW	RT	03/24/04
2195	M	A	NW	SR	03/24/04
1201	M	J	185	S	03/12/03
1205	M	J	180	HH	02/28/03
1220	M	J	180	NE	03/01/03
1223	M	J	200	WP	03/01/03
1224	M	J	175	WP	03/05/03
1229	M	J	185	S	03/01/03
1233	M	J	195	NE	03/05/03
1235	M	J	175	WP	03/05/03
1262	M	J	170	C	03/11/03
1277	M	J	180	S	03/11/03
1283	M	J	180	C	03/11/03
1284	M	J	185	S	03/11/03
1288	M	J	170	C	03/11/03
1289	M	J	180	C	03/11/03
1290	M	J	160	S	03/11/03
1322	M	J	180	S	03/11/03
1326	M	J	170	W	03/11/03
1328	M	J	185	FP	03/12/03
1331	M	J	180	FP	03/12/03
1333	M	J	185	W	03/12/03

1340	M	J	175	FP	03/12/03
1341	M	J	180	FP	03/12/03
1342	M	J	185	FP	03/12/03
1344	M	J	185	BC	03/13/03
1347	M	J	180	NE	03/13/04
1348	M	J	175	S	03/13/04
1355	M	J	180	NE	03/13/04
1360	M	J	185	NE	03/13/04
1367	M	J	180	C	03/17/03
1373	M	J	180	BC	03/17/03
1375	M	J	170	BC	03/17/03
1380	M	J	175	WC	03/17/03
1382	M	J	180	FP	03/17/03
1383	M	J	175	S	03/17/03
1384	M	J	175	NE	03/18/03
1385	M	J	175	FP	03/17/03
1387	M	J	180	WC	03/17/03
1392	M	J	165	DR	03/17/03
1394	M	J	180	FP	03/17/03
1395	M	J	165	NE	03/18/03
1396	M	J	185	FP	03/17/03
1400	M	J	185	FP	03/17/03
1601	M	J	175	S	03/18/03
1602	M	J	160	C	03/18/03
1606	M	J	165	FP	03/18/03
1606	M	J	NW	FP	03/18/03
1608	M	J	195	DR	03/18/03
1609	M	J	185	DR	03/18/03
1613	M	J	180	C	03/18/03
1615	M	J	190	S	03/18/03
1616	M	J	190	W	03/18/03
1617	M	J	170	DR	03/18/03
1621	M	J	175	WP	03/18/03
1624	M	J	185	DR	03/18/03

1625	M	J	190	DR	03/18/03
1626	M	J	175	W	03/19/03
1628	M	J	190	W	03/19/03
1629	M	J	190	W	03/19/03
1631	M	J	180	W	03/19/03
1632	M	J	175	W	03/19/03
1634	M	J	175	W	03/19/03
1635	M	J	180	W	03/19/03
1636	M	J	170	S	03/19/03
1641	M	J	170	WC	03/20/03
1642	M	J	160	WC	03/20/03
1649	M	J	180	WC	03/20/03
1653	M	J	180	WC	03/19/03
1654	M	J	190	S	03/19/03
1657	M	J	190	W	03/20/03
1664	M	J	180	W	03/21/03
1669	M	J	155	W	03/21/03
1670	M	J	170	W	03/21/03
1671	M	J	195	W	03/21/03
1676	M	J	NW	WC	03/22/03
1677	M	J	180	WC	03/22/03
1680	M	J	165	WC	03/22/03
1683	M	J	170	RF	03/22/03
1688	M	J	NW	FT	03/22/03
1691	M	J	175	S	03/21/03
1693	M	J	NW	RF	03/22/03
1695	M	J	NW	WT	03/25/03
1697	M	J	NW	SR	03/24/03
1698	M	J	185	S	03/22/04
1707	M	J	165	DR	03/25/03
1708	M	J	175	DR	03/25/03
1710	M	J	190	FT	03/25/03
1714	M	J	200	DR	03/25/03
1716	M	J	165	FT	03/25/03

1717	M	J	205	RF	03/25/03
1718	M	J	185	SR	03/25/03
1721	M	J	190	FT	03/25/03
1723	M	J	185	WT	03/26/03
1728	M	J	175	SR	03/25/03
1730	M	J	170	FT	03/25/03
1734	M	J	180	FT	03/25/03
1738	M	J	180	RF	03/26/03
1743	M	J	180	FT	03/26/03
1746	M	J	180	DR	03/26/03
1748	M	J	180	FT	03/26/03
1749	M	J	160	SR	03/26/03
1760	M	J	195	JY	03/26/03
1764	M	J	170	FT	03/26/03
1769	M	J	185	JY	03/27/03
1772	M	J	175	S	03/31/03
1776	M	J	180	WP	03/31/03
1778	M	J	165	LC	03/31/03
1779	M	J	180	RF	03/31/03
1781	M	J	205	JY	04/01/03
1782	M	J	170	C	04/01/03
1784	M	J	175	WT	04/01/03
1785	M	J	170	FT	04/01/03
1788	M	J	170	FT	04/01/03
1791	M	J	180	FT	04/01/03
1794	M	J	170	LC	04/01/03
1798	M	J	195	JY	04/01/03
1812	M	J	165	4W	04/08/03
1817	M	J	170	BH	04/08/03
1818	M	J	190	BH	04/08/03
1820	M	J	185	BH	04/08/03
1821	M	J	175	BH	04/08/03
1823	M	J	170	BH	04/08/03
1824	M	J	180	BH	04/08/03

1827	M	J	190	BH	04/09/03
1829	M	J	190	SD	04/09/03
1831	M	J	195	SD	04/09/03
1833	M	J	180	4W	04/09/03
1836	M	J	175	HWY	04/09/03
1840	M	J	190	BH	04/09/03
1843	M	J	185	BH	04/09/03
1847	M	J	185	BH	04/09/03
1871	M	J	160	BC	08/20/03
1872	M	J	165	BC	08/20/03
1880	M	J	165	WC	09/09/03
1881	M	J	190	WP	01/06/04
1883	M	J	170	WC	09/09/03
1891	M	J	180	WP	01/06/04
1896	M	J	170	WP	01/12/04
1897	M	J	190	WP	01/12/04
1898	M	J	205	WP	01/12/04
2001	M	J	185	WP	01/12/04
2004	M	J	210	WP	01/12/04
2005	M	J	185	WP	01/12/04
2032	M	J	NW	FP	01/14/04
2044	M	J	200	JY	01/16/04
2047	M	J	190	WC	01/16/04
2060	M	J	NW	FP	01/16/04
2066	M	J	175	S	02/26/04
2075	M	J	180	WC	02/26/04
2077	M	J	190	WC	02/26/04
2082	M	J	165	WC	03/02/04
2084	M	J	175	WC	02/27/04
2086	M	J	190	WC	02/27/04
2087	M	J	170	WC	03/02/04
2088	M	J	190	WC	02/27/04
2103	M	J	180	WC	03/09/04
2113	M	J	180	S	03/10/04

2117	M	J	180	SR	03/09/04
2119	M	J	180	S	03/09/04
2123	M	J	185	SR	03/10/04
2135	M	J	175	FP	03/11/04
2143	M	J	195	FP	03/11/04
2146	M	J	165	FT	03/16/04
2151	M	J	185	FP	03/11/04
2155	M	J	180	FP	03/15/04
2163	M	J	170	S	03/16/04
2164	M	J	165	S	03/16/04
2167	M	J	180	NE	03/19/04
2176	M	J	NW	RT	04/05/04
2181	M	J	170	WM	03/19/04
2187	M	J	185	RT	04/14/04
2190	M	J	170	RT	03/24/04

APPENDIX C.
Nesting data for bobwhites in Fisher County, Texas, 2003-2004

Hen[1]	Age	Date found	Eggs	Substrate	Fate
150.816	A	5/5/2003	19	Three-awn	destroyed
150.876	S	5/5/2003	16	Yucca	destroyed
151.476	S	5/7/2003	11	Texas wintergrass	destroyed
150.415	A	5/16/2003	9	Texas wintergrass & lotebush	hatched 8 eggs
150.495	S	5/16/2003	10	Three-awn	destroyed
150.025	A	5/19/2003	11	Texas wintergrass	hatched 11 eggs
151.585	A	5/19/2003	12	three-awn associated with yucca	destroyed
151.024	A	5/20/2003	12	Texas wintergrass & mesquite	destroyed
150.434	S	5/20/2003	16	Texas wintergrass & pricklypear	destroyed
151.133	S	5/29/2003	>12	Texas wintergrass	destroyed
151.065	S	6/2/2003	N/A	Texas wintergrass & pricklypear	hatched 6 eggs
151.345	A	6/5/2003	N/A	Three-awn	destroyed
150.535W	S	6/5/2003	11	Three-awn associated with yucca	hatched 10 eggs
150.145	A	6/11/2003	11	Texas wintergrass associated with yucca	hatched 8 eggs
150.535BC	S	6/11/2003	N/A	Three-awn associated with yucca	hatched
150.454	A	6/18/2003	10	Dead yucca	abandoned
150.755	A	6/18/2003	17	Texas wintergrass	destroyed
151.110®	S	6/19/2003	13	Texas wintergrass	hatched
150.675	S	6/24/2003	10	Texas wintergrass associated with ppear	destroyed
151.776	S	6/24/2003	11	Vine mesquite	hatched 10
151.125	A	6/25/2003	10	Silver bluestem associated with yucca	destroyed
150.085®	S	6/25/2003	12	Texas wintergrass	hatched 11eggs
151.585	A	6/27/2003	14	Vine mesquite	abandoned
151.564	A	6/30/2003	14	Texas wintergrass and pricklypear	Hen killed
151.926	A	6/30/2003	10	Yucca	destroyed
150.800®	A	7/1/2003	11	Texas wintergrass associated with ppear	destroyed
150.911	S	7/1/2003	12	Texas wintergrass	destroyed
151.685	A	7/2/2003	14	Texas wintergrass and pricklypear	destroyed
151.275	S	7/2/2003	N/A	Texas wintergrass	destroyed

151.024	A	7/3/2003	6	Yucca	destroyed
150.635	A	7/7/2003	9	King Ranch bluestem	destroyed
150.816	A	7/9/2003	13	Texas wintergrass and pricklypear	hatched 12 eggs
150.353	A	7/15/2003	N/A	Sideoats grama and pricklypear	destroyed
150.415	A	7/15/2003	8	Texas wintergrass and pricklypear	destroyed
150.809	A	7/15/2003	N/A	Texas wintergrass and pricklypear	destroyed
150.771	A	5/2/2004	18	Meadow dropseed	destroyed
151.499	S	5/2/2004	13	Prickly pear and three-awn	hatched
150.235-P	S	5/5/2004	13	Johnson grass	destroyed
150.795	S	5/7/2004	14	Texas wintergrass in pricklypear	hatched
150.546	A	5/10/2004	10	Prickly pear and Texas wintergrass	destroyed
151.265	A	5/10/2004	N/A	Tobosagrass	destroyed
150.204	A	5/12/2004	7	Texas wintergrass in pricklypear	destroyed
151.678	S	5/13/2004	N/A	Texas wintergrass in pricklypear	destroyed
151.632	S	5/17/2004	12	Texas wintergrass in pricklypear	hatched 11 eggs
150.761	A	5/19/2004	15	Texas wintergrass in pricklypear	hatched
150.526	A	5/20/2004	19	Texas wintergrass in pricklypear	hatched
150.959	A	5/20/2004	>=7	WW bluestem	destroyed
151.320	A	5/28/2004	13	Three-awn	hatched 11 eggs
150.950	A	5/28/2004	9	Three-awn	hatched
150.680	S	5/28/2004	11	Three-awn and pricklypear	hatched
150.771	A	6/1/2004	12	Plains bristlegrass	hatched 7 eggs
151.146	A	6/3/2004	7	Silver Bluestem	destroyed
151.428	S	6/3/2004	15	Three-awn	hatched
151.338	A	6/7/2004	7	Texas wintergrass at base of mesquite	hatched 6 eggs
151.554	S	6/8/2004	12	Texas wintergrass in pricklypear	destroyed
150.804	S	6/8/2004	10	Texas wintergrass in pricklypear	hen killed
151.678	S	6/8/2004	11	Three-awn and pricklypear	hatched
150.635®	A	6/11/2004	8	Three-awn	destroyed
150.921®	A	6/11/2004	9	Three-awn and pricklypear	hatched 5 eggs
151.283	S	6/15/2004	N/A	white tridens in pricklypear	destroyed
150.546	A	6/16/2004	10	Texas wintergrass in pricklypear	hatched
150.897	A	6/16/2004	15	Texas wintergrass under lotebush	hatched
151.380®	A	6/16/2004	9	Three-awn	hatched

150.645	A	6/22/2004	11	Prickly pear and lazy daisy	hatched
150.671	S	6/22/2004	N/A	Yucca	destroyed
150.473	A	6/25/2004	13	Three-awn and pricklypear	hen killed
151.031	S	6/28/2004	15	Texas wintergrass in pricklypear	hatched 9 eggs
151.146	A	6/29/2004	11	Texas wintergrass under tasajillo	destroyed
151.312®	A	7/2/2004	11	Sideoats grama	destroyed
151.499	S	7/5/2004	13	Three-awn and pricklypear	destroyed
151.229®	A	7/7/2004	N/A	Three-awn	destroyed
150.950	A	7/7/2004	10	Yucca and three-awn	hatched
150.959	A	7/16/2004	N/A	Texas wintergrass under tasajillo	destroyed
151.554	S	7/26/2004	10	Texas wintergrass under lotebush	hatched
150.587®	A	7/28/2004	9	Yellow indiangrass	hatched
151.146	A	8/17/2004	10	Texas wintergrass in pricklypear	censored
150.959	A	8/17/2004	14	Hackberry and Dayflower	hatched
150.644	A	8/17/2004	12	Texas wintergrass in pricklypear	hatched

[1]® denotes a male incubation

VITA

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Jason Lee Brooks was born on 2 December 1979 in Stanton, Texas. He is the son of Russell and Cindy Brooks. Jason was a member of the 3rd generation of Brooks' to attend Greenwood Schools. Upon high school graduation, he enrolled at Angelo State University. After his sophomore year, Jason accepted an internship with the Texas Agricultural Extension Service (now Texas Cooperative Extension). This position provided him an introduction to the wildlife field. After graduating from ASU, Jason took a graduate research position as the primary field investigator on the Fisher County Quail Project. Jason will graduate with a Master of Science degree from Texas A&M University in May 2005.